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ENGINEERING AND MINING JOURNAL

A Consolidation of Engineering and Mining Journal and Mining and Scientific Press

METAL AND NON-METALLIC MINING · MILLING · SMELTING · REFINING · MARKETING

Magmas, Dikes and Veins

By Waldemar Lindgren

•

Magmas, Dikes and Veins

By J. E. Spurr

Underground operation as well as surface work is necessary at the West Rutland quarry of the Vermont Marble Co. The deposit, which is only 50 ft. thick, goes down almost vertically for 200 ft., then turns nearly 90 degrees and runs back under the mountain. Excavation by tunneling and channeling has been extended over an area beneath the surface about 2,000 by 600 ft. in extent. The roof is supported by pillars. Photo by Ewing Galloway, New York

Useful Operating Ideas

Dump Doors for Shaft Sinking

Side Arm Collector for Electrified Open Pit Haulage

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For all needs of the industry

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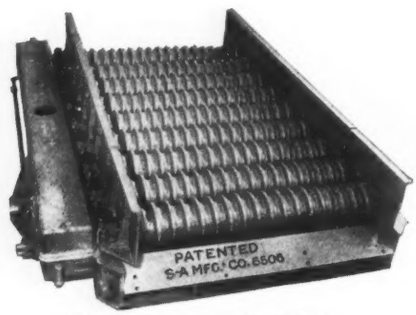
Third—There is no vibration. There is therefore very little wear on the driving mechanism.

Fourth—The action of the screen is smooth. There is practically no breakage of the product being handled.

Fifth—The action of the screen is such that it serves to a certain extent as a feeder.



The S-A Live Roll Grizzly

Sixth—The increasing speed of each successive spool serves to thin out the load as it passes over this grizzly.

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Eleventh—There is practically no chance of clogging.

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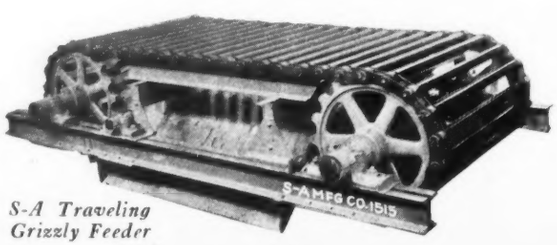

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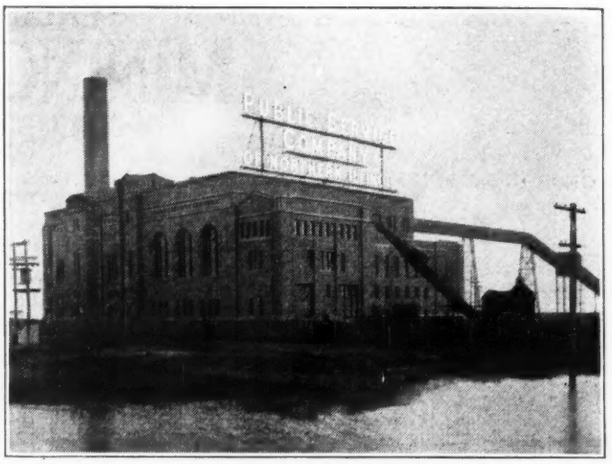
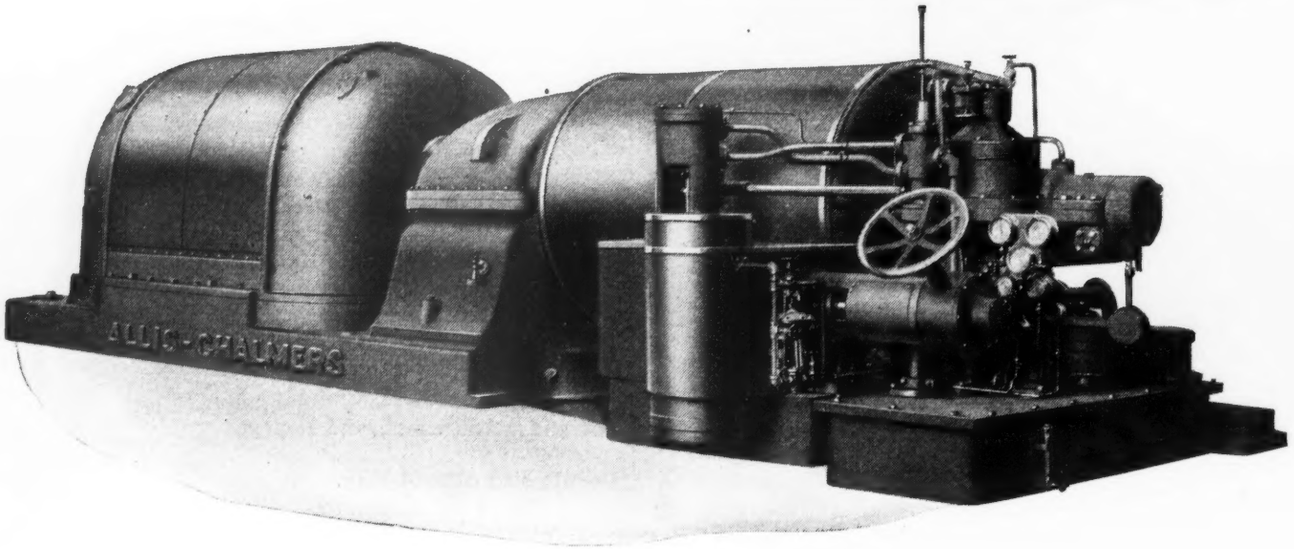
Some Instances of

Dependability

In

Allis-Chalmers STEAM TURBINES





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ENGINEERING AND
MINING JOURNAL

JOSIAH EDWARD SPURR, Editor

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Rocking the Copper Boat

COPPER PRODUCERS will fare best in the long run with a steady, stable market at a price that will assure a reasonable profit. Wide and sudden fluctuations are bad: a quick climb to unwarranted price levels, brought about by conditions that are only temporary, is inevitably followed by a painful reaction. The tendency is for consumption to be restricted, for production to be expanded, and for the orderly and efficient conduct of the industry to be disrupted. This is harmful to the producer.

In the *Wall Street Journal* of July 13, appears a column-and-a-half article captioned "Copper Industry Faces Shortage." Excerpts of the same article appear in the *Boston News Bureau* of the same date. Most of the specific data in the article are accurate and the analysis of the situation is, for the most part, sound, except for exaggeration.

Unquestionably there are at the moment very limited stocks of actual copper at the refineries in the shapes that are in demand. This shortage is likely to be accentuated by the necessity of curtailing output at one of the large refineries for sixty days as a consequence of serious furnace trouble. But any difficulty in supplying consumers with needed copper can, in any event, be only temporary.

The writer of the article referred to paints a sensational, if misleading, picture of a copper-mining industry that must strain itself to meet the needs of industry. He says, "In the present situation the only safe plan is for fabricators to begin as quickly as possible to contract for their requirements as far ahead as they can foresee them. This will inevitably result in higher prices for the metal." His conclusion is sounder than his advice. If a large majority of the copper buyers should be stampeded into rushing precipitately into the market the present squeeze would be aggravated, and the very thing that producers do not want would probably happen; that is, the price would unavoidably be hoisted to a point from which it later would have to take a severe tumble, with harm to all concerned with the copper industry. Consumption is going to increase steadily, and production will be increased to meet it; that the price level of copper will improve moderately is not unlikely. It is to be hoped that this comes about in orderly fashion; but propaganda like that of the *Wall Street Journal*, calculated to throw consumers into a panic, is not going to help.

Another angle to this situation: When copper goes up, copper shares almost invariably follow. In Wall Street the "coppers" have been stagnant for a long time, but if the price for the metal is boosted the accommodating public, stimulated by the ballyhoo of the brokers, will come into the share market and send up stock prices. If the metal goes to levels that are unjustified by fundamental conditions, the same thing is more than likely to happen to the shares, and a reaction will follow. The only people who can possibly benefit by an artificial and excessive inflation of prices for copper are the speculators, traders, and insiders in Wall Street—and incidentally the brokers. What these folks want is action; whether it is up or down is immaterial to them, so long as price levels move over a fairly wide range and with some celerity.

The best course for buyers of copper for consumption, as well as for copper producers, is to keep cool; buyers should not force the market and sellers should bend their efforts toward keeping the market in hand. At the same time it may be suggested that those consumers who have been buying from hand to mouth could profit from the lesson of the existing condition by covering their future requirements farther ahead when the situation is eased. Any improvement in price that is justified by basic conditions will develop in the natural course of events; any temporary spurt stimulated by exaggerated propaganda can help no one but professional Wall Street, and will hurt the copper-mining industry.

Mexico Again

IN A LETTER recently made public, J. Grant Hinkle, Secretary of State of Washington, is quoted in the newspapers as saying: "I happen to know something of the Mexico country and their people. No sane man would invest in any property under present conditions in Mexico, and I am advising all inquirers to that effect."

The purpose of the letter was to advise the vendors of shares of a certain mining company operating in Mexico that they were not qualified to do business in the State of Washington. Mr. Hinkle's action in this particular case may have been fully justified; but his out-of-hand damning of all mining enterprise in Mexico is not warranted. Many companies are not only operating in Mexico, but are acquiring new interests there; and these companies are not managed by men who are by any means demented. That political and social conditions are far from being ideal is not to be denied; but if the disadvantages are all put in the scale they are outweighed by the advantages—not the least of which is the existence of very rich deposits of ore.

Millions upon millions in dividends have come out of Mexican mines, and they will continue to do so, despite the gloom that pervades the mind of Mr. Hinkle.

The Pittman Silver-Purchase Bill

WHEN CONGRESS RECONVENES it will have before it the Pittman silver-purchase bill, which has passed the Senate and still has to pass the House. This bill calls for the purchase of 14,589,730

oz. of silver at $1 per ounce to replace that taken from the Treasury vaults under the authority of the original Pittman Act, but then allocated for subsidiary coinage instead of for sale to Great Britain as the act intended. Because it was so used, officials of the Treasury deemed it unnecessary to replace this silver by repurchase at $1 per ounce, although the law definitely prescribed it. Great controversy raged around this point in 1923, when repurchases under the original Pittman Act were declared completed. When finally it became evident that nothing was to be done by appeal to Treasury officials or the Comptroller General, Senator Pittman introduced a resolution in Congress instructing the Secretary of the Treasury to purchase the amount of silver necessary to cover the amount allocated for subsidiary coinage. This first resolution passed the Senate, but died in the last session, in 1925, before it could pass the House. Again Senator Pittman introduced his resolution, and again it passed the Senate and now awaits the next session for consideration by the House.

The resolution has its enemies, however—in particular a very able enemy in the Senate in the person of Carter Glass, who, though the Senate had adopted the resolution unanimously in his absence, almost succeeded in securing its reconsideration. It was while Senator Glass was Secretary of the Treasury that most of the silver in question was used for subsidiary coinage. So the friends of the measure should not delude themselves that its final enactment into law is practically certain. Sustained effort to secure its passage is still essential. All that the resolution asks is that the law be complied with as set forth in the original Pittman Act. The silver producers have sought no more than justice.

A Graduate School of Mining Administration

THAT MINING IS A BUSINESS, and that this should be recognized in the training of mining engineers for their life work, has been stressed many times in these editorial pages during the last few years. There has been a corresponding tendency among mining schools to recognize this development, indicated by the establishing of courses shaping in this direction—as, for example, the proposed course in economics which will be part of the curriculum of the resuscitated Harvard mining course. But by far the most radical innovation in this line is the graduate course in the Administration of Mineral Industries, just established by the College of Mines and Engineering of the University of Arizona. This course, which is offered for 1926-27, is under the direction of Dr. E. P. Mathewson, and will comprise five months of formal study of economic problems and four months of "field work" in the large properties of Arizona. The course, as described on page 112 of our issue of July 17, comprises accounting, business finance, organization, administration and management, and money and banking. It is to be hoped that a specific study of the marketing and distribution problems of metals and minerals will be added to this curriculum.

Another subject on which a clearer understanding is imperative is the connection and interlocking of mining and manufacturing—that is to say, of the mining industries and the metal and other manufacturing trades. A knowledge of this borderland and a general conception of what lies on both sides of it are necessary now and will be more so in the future. Another subject that might well be made the basis for academic study is mine promotion. Possibly this is included in the proposed course on business finance, but it should be applied specifically to mine promotion problems.

Students in this course must be graduates in mining engineering from some school of standing, and must have had a minimum of three years' practical experience since college; they must be selected and highly endorsed by employers, before they may enroll. And the candidate for the course must agree to return to his position at the end of the course at no higher salary than when he left.

This development is in line with the establishment at many universities of Graduate Schools of Business, which have flourished and have proved their utility. The innovation at the University of Arizona is welcome, and should prove successful. Perhaps the admission requirements are too rigorous, and this may militate against immediate success. A simple requirement of graduation in mining engineering would perhaps establish a sufficiently high standard. A good time for the mining engineer to get a conception of mining in all its phases, including its predominant business phase, is when he is at college, in the normal course of his development. It is difficult for a man to break away and go back to school after he is well launched in life, has left school, and is cleaving his way. Life is paved with the unfulfilled intentions of graduates to return to school later for further scholastic training, after they have made a little money and gained a little outside experience. The tendency is for the successful ones—that is to say, the more forceful ones—not to return; the tendency is rather for those who have been baffled to go back and seek further training. The present plan of the Arizona College of Mines depends for its success wholly—indeed too much—upon the co-operating companies.

Electrolytic Iron

IN A RECENT REPORT to the Engineering Foundation it is estimated that twenty million tons of iron and steel are lost annually through corrosion alone. In addition to this there are enormous quantities of scrap that disfigure the countryside in the form of cans, machinery, automobiles, and other articles made in whole or in part from iron, to reclaim which no attempt is made. Experiments indicate that by dissolving scrap iron by ferrous chloride, or other solvents, a recovery by electrolysis would save the waste due to discard, and at the same time produce an iron at a reasonable cost that will rust less rapidly or not at all. By this method it may be possible to recover the iron content of low-grade ores that cannot be smelted.

For centuries past fire has been the only means of extracting the iron from the ore, all of which means enormous shipments of ore, flux, and fuel to some suitable central place to meet modern requirements. The report states that at Niagara Falls electrolytic iron of a purity of 99.96 per cent is being produced, while research and developments are going on. This iron is said to be resistant to corrosion and has other physical qualities that make it desirable in preference to the furnace product. As our iron mines are being depleted at a rapid rate, every encouragement should be extended to all those engaged in research along these lines.

The Value of Outrageous Hypotheses

FROM A RECENT ISSUE of *The Forum* the following is quoted referring to an article that had been published in *Science:*

"And now comes Prof. W. M. Davis, of Harvard, to assure us not only of the value of hypotheses, but of the value of outrageous ones. Speaking as a geologist, he assures his fellow scientists that since the great advances of geology in the past have been made by outraging in one way or another a body of geological opinion, we may be pretty sure that the advances yet to be made in geology will at first be regarded as outrages upon the accumulated convictions of today, which, as the modern substitute for Genesis itself, we are too prone to regard as geologically sacred."

If this is striking, and if it is true, it is nevertheless not new. The observation has been repeated over and over again in retrospect, looking back to the time when Galileo was in prison because of his outraging and impious hypothesis that the earth is round, or the time when Professor Langley died broken-hearted at the Congressional ridicule because his perfectly practical airplane—the first to be developed—accidentally crashed at the first trial. Nevertheless, the experience will be repeated in all future time, for the human mind can only perceive this when it becomes history—when the outrager becomes the prophet, when the cross is replaced by deification.

The human mind craves hard and fast tenets—things to which it can hold—and the attack on these, whether they be religious or scientific, is disturbing, irritating, and even angering to the nerves and to the brain. Especially is this true of those older men in whose minds the tenets have dug deep with repetition; and especially in those who have studied hard and built much upon them as foundations.

Recent discussions in economic geology reveal the existence of the instinct to dislike the ghosts of skepticism and to regard the skeptic, the proposer of a new and substitute hypothesis, as an unruly and in some way culpable disturber of the peace—that great peace, especially, which settles on many universities, where students strive to memorize the august words which fall from the professor's lips, and the professor is by this atmosphere lulled into the delicious feeling that he has attained the restful Nirvana of knowledge in his specialty.

One is reminded of Patrick Henry's cry—"Gentlemen may cry Peace—peace! but there *is* no peace." There is no restful Nirvana in science. A complete and restless and abiding system of change and exchange of trials and new concepts and closer approximations are in store for the world, and will be forever necessary to the advancement of knowledge.

State Aid for the Miner

ANOTHER CO-OPERATIVE MARKETING scheme sponsored by the state to aid miners in disposing of their product is reported from Australia. The Tasmanian Government has proposed a plan for helping the producers of osmiridium in the Adams River field. A co-operative company in which all the miners would be shareholders has been suggested. Sixty per cent of the current London price would be advanced by the Commonwealth Bank, whose agents would ship the metal to England. Evidently the government seeks to stimulate production, which of late has been falling off. From a production of 332 oz. in 1917, valued at less than £5,000, the peak was quickly reached in 1920, with an output of 2,009 oz. valued at £77,114. By 1923 production had declined to 673 oz., and in the following year an output of only 365 oz., valued at £10,617, was reported. Osmiridium is being saved on the Rand and in Rhodesia, but, on the other hand, it is said that it is becoming increasingly more difficult to find throughout Australia.

In the Anakie sapphire fields, in Queensland, which to date have produced between $2,000,000 and $3,000,000 worth of stones, for several years past the State Government has aided the miners in selling their production. Under the latest plan, which came into force in 1923, the gems are bought outright by the government, and 95 per cent of a grader's valuation is paid to the miners, the remaining 5 per cent being retained to cover expenses. Results under this plan have been somewhat better than under the scheme formerly in vogue, which gave the miner a much smaller return and consequently produced a smaller output of gems.

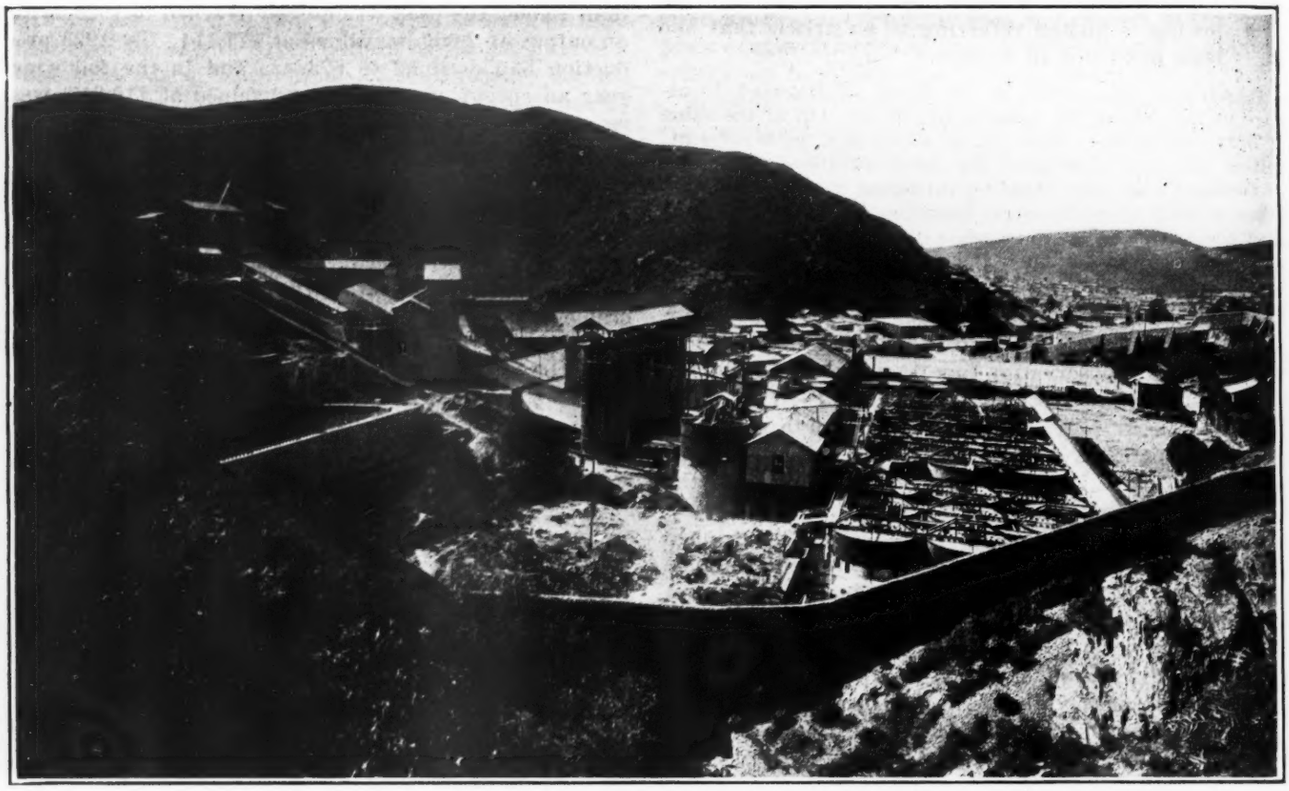
Coddling of this sort by government costs something, and a good part of the cost is likely to be paid by those who are not benefited. Government aid that makes possible the otherwise impossible is justified only where the existence of an essential industry is at stake or where it is desired to stimulate the development of such an industry to the point where it will be enabled to stand alone.

Too Rapid Oil Production

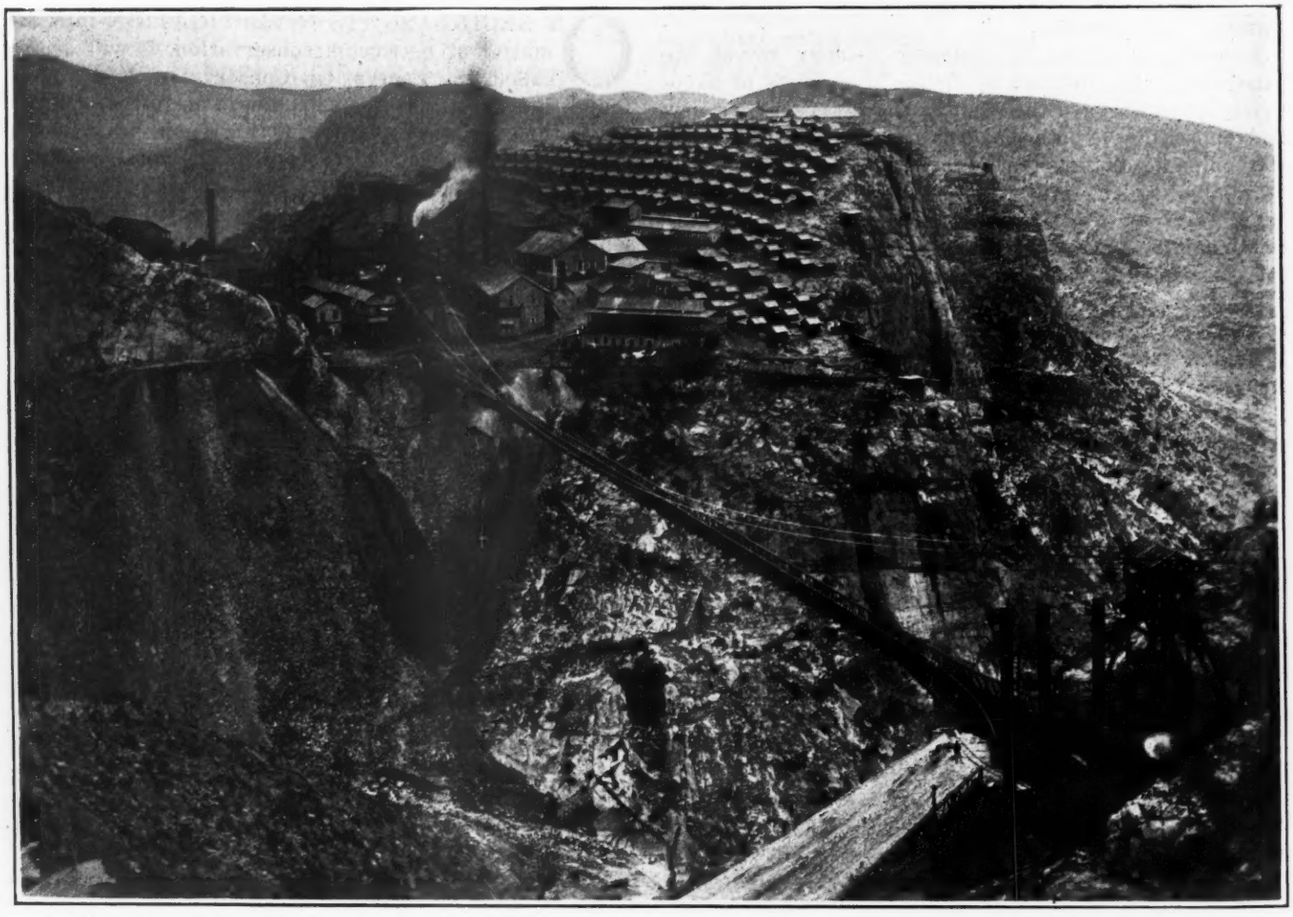
ON BEGINNING ITS INVESTIGATION into the matter of petroleum conservation, it will be recalled, the Federal Oil Conservation Board soon found that the government itself was an important factor in the current production of petroleum, having been responsible for over 14 per cent of the total domestic output in the fiscal year 1923-1924. On his recent appearance before the board, ex-Secretary Hughes, representing the American Petroleum Institute, pointed out that a policy of delaying production or of retaining petroleum in the ground until it is thought to be needed, from an economic viewpoint was directly contrary to the existing policy of the government as reflected in the Federal Leasing Act of 1920 and the permits and leases issued under it, and in certain forms of oil leases prescribed for use in connection with Indian lands. The present Federal system, according to Mr. Hughes, seems to call for prompt, continuous and competitive drilling, as distinguished from the unified development and operation of an oil pool having as its underlying object the retaining of the oil in the ground until it is needed. Mr. Hughes cites sufficient evidence to prove his point, and so makes the government appear rather more of an offender than before, provided that the country's petroleum resources are really being drawn upon too heavily and too rapidly. He sees no reason for worrying about the rapid depletion of reserves, however, taking the position that economic laws aided by progress in technology will apply the proper corrective.

Mr. Hughes' position is in accord with that of the Committee of Eleven of the Institute, as befits an attorney retained to represent that body.

Mining in Mexico—Two Outstanding Operations



At Pachuca, Hidalgo—The Loreto concentration-cyanidation mill of the Real del Monte y Pachuca company, subsidiary of the United States Smelting, Refining & Mining Co.



Near Mapimi, Durango—The Ojuela mines of the Peñoles company, owned by the American Metal Co.

Magmas, Dikes, and Veins*

By Waldemar Lindgren

NO ONE WOULD MAINTAIN that all ore deposits or all deposits of useful minerals have been formed by the same processes. Generally they have originated by special processes of concentration, but these may be of many different kinds. Some deposits have their origin in chemical or biochemical processes of concentration in rivers, lakes, or seas; others developed on land by means of chemical reactions of surface waters on various forms of rocks. Certain insoluble substances remained behind; others were dissolved and precipitated in favorable places. This action proceeded in the realm of the oxidizing surface waters or in the deeper zones to which the waters from the surface could find their way. Examples of the latter kind may be found in the extensive copper and vanadium deposits of some sedimentary beds or in the lead and zinc deposits of certain broad limestone strata. In these instances the evidence for any other mode of origin would seem to be very weak indeed.[1] Nor does it seem possible to deny that circulating waters may form deposits of the more common metals along fissures after having dissolved many constituents from paths traversed.

Another very large class has been formed by magnetic processes of concentration.

The last forty years have been a period of intense activity in the investigation and description of a vast number of deposits; all modern methods have been employed, and the result is an accumulation of data, difficult or impossible to master. It has been a period similar to that in petrography. The generalizations, the able deductions, have lagged behind. Evidently several geologists have become weary of this "infinite detail," and a mistrust of the microscope seems to have arisen. Although this feeling of being swamped in microscopic detail is a painful experience, nevertheless only through the detail in combination with the large features, and only by utilizing all the related sciences, shall we be able to attain the truth. Disaster lurks in the return to the physical methods of pre-microscope and pre-chemistry days. What is needed, but what is not yet in sight, is the master who can combine in his mind the large and the small, the structural features and the story of the microscope.

The following pages contain a brief discussion of that group of mineral deposits that the writer holds have been formed by processes of concentration originating in the molten magmas.

Review of Theories of Various Geologists

The reason why a large part of the mineral deposits, particularly of those that carry rarer elements, has been concentrated by processes of differentiation in magmas is because in a complex solution like the magma there is most excellent opportunity, as temperature and pressure varies, to split off elements by fractional crystallization, by the development of salic extracts (source of pegmatite dikes), and by gas fluxing. Combined with mineralizers, such as chlorine, sulphur, fluorine, phosphorus, arsenic and boron, the heavy metals will very readily escape from the melt and ascend into cooler rocks, where they may condense and form deposits. This theory, brought forward by the genius of Elie de Beaumont long ago when but little was known of the character of the magmas, was for a time generally accepted, at least in France. One is surprised in reading[2] Burat's *Geologie Appliquée* (1853) how fully the genetic connection of igneous rocks and ore deposits is recognized and how clearly the ore zones are outlined.

Later on, the ground gained was lost by the advancing of an elaborate theory of the circulation of waters of surface origin, so that in the views of Daubrée and De Launay there is but little left of de Beaumont's generalizations. Later came Sandberger, with the theory of lateral secretion, and the best that Stelzner and Posepny could do in opposition to him was to uphold the derivation of the ore-depositing waters from an indefinite deeper zone.

Vogt's rejuvenation of the magmatic theory of ore deposits[3] about 1895 was a great step in advance, and he soon won adherents in this country. The teachings of Van Hise, with his insistence on universal circulation of surface waters and their supposed universal powers of leaching and deposition, gradually faded away. At present the magmatic theory holds full sway; many have contributed to it; no one in our country can be regarded as the sole proprietor of it. While it is not intended to present a full history of the magmatic theory outside of this country, no account would be at all complete that left out the name of Richard Beck, who soon after the appearance of Vogt's papers in 1893-95 became an enthusiastic advocate of this doctrine.

Van Hise in 1896, A. C. Lane about the same time, Spurr[4] in 1898, Crosby[5] in 1897, and others had recognized the transition between pegmatite dikes and quartz veins of magmatic origin. Spurr had maintained the continuity of the series into the gold-quartz veins.

The conception that waters of hot springs were of magmatic origin took form about twenty years ago, and this theory has been extensively discussed up to the present time. Kemp,[6] in 1901, confessed his adherance to the magmatic theory and his belief that magmatic waters had formed most of the ore-bearing veins. In 1922 he restated his views in a notable presidential address. Many investigators have held that these hot waters are the agents of deposition, but that their pure magmatic origin is a matter of considerable doubt. Most of them are probably mixed products of magmatic material, circulating surface waters, and material dissolved from the country rock. The valuable metals and the rarer ingredients are usually held to have been derived from the magmas.

It is quite certain that the impulse toward the mag-

*Presented at the New York meeting of the American Institute of Mining and Metallurgical Engineers, February, 1926.

[1]It is interesting to observe that in the vanadium-copper deposits in sedimentary rocks, rare elements like vanadium, molybdenum, nickel selenium, chromium, and silver have been concentrated to a notable degree.

[2]Amédée de Burat: Geologie Appliquée. Paris, 1853.

[3]J. H. L. Vogt: *Zeit fur prakt. Geol.* (1893, 1894, 1895).

[4]J. E. Spurr: U. S. Geological Survey Annual Report 18, Part 2, 1898, pp. 87-392.

[5]W. O. Crosby and M. L. Fuller: *American Geology*, Vol. 19, 1897, pp. 147-180.

[6]J. F. Kemp: Trans. A.I.M.E., Vol. 31, 1901, pp. 161-198; *Bull.* G.S.A. 33, 1922, pp. 231-254

matic theory was given by the papers of J. H. L. Vogt in the 90's, though Posepny, himself an opponent of Vogt, and Stelzner had paved the way by assuming a derivation of the hot waters from the "barysphere." About 1900 the theory was actively discussed among a group of American geologists. The writer remembers these discussions very vividly. They culminated in 1903 at a meeting of the Geological Society of Washington[7] when W. H. Weed contributed a classification of ore deposits of more or less direct magmatic origin. It will be found that this classification differed but little from that now accepted by many geologists. Most veins were believed to have been formed by magmatic waters admixed with waters of surface origin. In the long discussion following S. F. Emmons and F. L. Ransome did not fully approve of the proposed classification, while Lindgren supported Weed. Spurr presented a classification in which the direct magmatic origin of gold-quartz veins was advocated, but which otherwise showed but little similarity to his present views.

The writer, after having acknowledged the probability of the magmatic theory in 1900, ventured, in 1906, to present a division of veins and replacement deposits[8] based on the physical conditions at the time of formation.[9] Though to great degree these zones corresponded to depth, the division was essentially according to temperature and pressure prevailing. The shallow, the intermediate, and the deep zones were distinguished, since[10] renamed the epithermal, mesothermal, and hypothermal.

In 1907, the writer[11] attempted to clarify his position in a paper in *Economic Geology*, in which explicit adherence to the magmatic origin of a large group of deposits was affirmed. In 1907 Spurr[12] outlined his "magmatic theory" and his "zonal theory" in a paper which brought a sharp rejoinder from Ransome[13]. In 1912[14] he still further elaborated his conclusions.

W. H. Emmons[15] in 1908 ranged himself with the geologists who hold to the magmatic theory; in 1924 he wrote an important paper[16] dealing with the "zonal theory" or changes in depth of ore deposits.

In 1918, W. H. Goodchild, of London, presented an important contribution to the subject in a paper entitled "The Evolution of Ore Deposits From Igneous Magmas."

In 1923 Spurr published a book in two volumes, entitled "The Ore Magmas," which may be accepted as embodying his experience and conclusions in regard to ore deposits. This was followed by an extensive series of papers, among which those listed at the close of this paper may be regarded as the more important[17].

A brief summary of Spurr's views follows, as the writer shall later have to express his own opinions, which differ in many points from those of the author mentioned. This paper is not to be considered in the nature of a polemic. Spurr's consistent presentation of his views is greatly to be admired. The writer has benefited from the results of his many data on ore deposits in different parts of the world, and, indeed, agrees with him in many respects. Nevertheless, he has gone much too far, and the writer believes that some of his conclusions will not stand the test of the sober judgment of physical chemistry. Lest silence may be deemed acquiescence, the writer has ventured to present his own views.

There will be occasion to write down opinions differing from those of other men, all of them, like Spurr, good friends of the writer. These opinions may be wrong. Time will tell. But free discussion is the key to progress; free discussion we must have.

SUMMARY OF SPURR'S VIEWS

The majority of ore deposits are termed "veindikes" because they are essentially intrusive masses formed by the injection of the "ore magma." The ore magma is produced, not during the normal cooling of the igneous rock, but during very slow and long continued differentiation of magmas at very great depths, and they are forced up by "telluric pressure." Volcanic emanations, therefore, do not represent ore magmas. The ore magma is often highly concentrated and viscous, but vein solutions have the property of intimate penetration and replacement of the rocks traversed, indicating in these cases much thinner solutions. As examples of "veindikes" are given Californian, Canadian, and Victorian gold-quartz veins, the Cobalt veins, the Camp Bird veins, the Bolivian tin veins, the United Verde deposit in Arizona. In fact, it appears that all ore deposits, whether of replacement type or not, are "veindikes," or injected ore magmas.

The escaping gases from the ore magma into the country rock are held to induce precipitation of the metals. Deposits carrying mainly cinnabar and stibnite are deposited from hot-spring waters. These latter solutions are far different from magmatic solutions which have penetrated the rocks as "veindikes." The hot springs are the aqueous residue from real ore magmas which nowhere reached the surface. Spurr differentiates between the siliceous ore magmas derived from acidic rocks and basic ore magmas which are rich in sulphides and poor in gangue materials.

In part, the ore magmas appear to have been gels, and this is not confined to the siliceous ore, but also to the pyrite-carbonate veindikes, of which it is said that "they were injected as a pyrite-carbonate magma, intruded in a gelatinous state, in a condition between solution and crystallization."

In the classification of ore deposits the gangue minerals, such as tourmaline or calcite, are of little importance. Speaking of Peñoles, Mexico, it is said that the vein fluid up to the calcite stage was stiff or viscous. Hardening of the gel must have swiftly followed intrusion. The gels contained some water, which produced silicification of the country rock. A deep plutonic sequence of vein deposition is discerned, which may extend over a space of 25,000 to 30,000 ft. An interesting example is given from Ojuela, near Peñoles, where the ore zone is 3,500 ft. deep, passing from the chalcopyrite and arsenopyrite stage in depth to the lead-zinc stage and, still further up, to the silver stage; above this stage the veins are barren, with siderite and calcite for 2,500 ft.

The upper vein zone, within 3,000 ft. of the surface, in volcanics, presents a separate and distinct sequence

[7] *Engineering and Mining Journal*, Feb. 14, 1903.
[8] W. Lindgren: Posepny Volume, A.I.M.E., 1901, p. 611; International Geological Congress, X, Mexico, 1906; *Economic Geology*, Vol. 2, 1903, pp. 105-126.
[9] It is a small matter, but Spurr is in error when he dates this paper, or the views expressed in this paper, from 1919: "The Ore Magmas," Vol. II, p. 434.
[10] W. Lindgren: *Economic Geology*, Vol. 17, 1922, pp. 292-294.
[11] W. Lindgren: *Economic Geology*, Vol. 2, 1907, pp. 743-762.
[12] J. E. Spurr: *Economic Geology*, Vol. 2, 1907, pp. 781-795.
[13] F. L. Ransome: *Economic Geology*, Vol. 3, 1908, pp. 420-425.
[14] J. E. Spurr: *Economic Geology*, Vol. 7, 1912, pp. 485-492.
[15] W. H. Emmons: *Economic Geology*, Vol. 3, 1908, pp. 611-627.
[16] W. H. Emmons: *Trans.* A.I.M.E., Vol. 70, 1924, pp. 964-997.
[17] Bibliography. Pamphlet 1,575-I, A.I.M.E. June, 1926, p. 22.

from high-temperature minerals, such as tin and wolfram, to the complex silver ores. The result of rapid precipitation in this zone is that the ores of the different vein zones are quickly superimposed or "telescoped." If rightly understood, Spurr says the ore magma of the upper zone came from the same source as that of the deep zone, but held the metals in solution longer, for the magmas which reached the surface arrived there with a temperature hotter than that which they had in depth. The total metal content was precipitated within the upper 3,000 feet.

The existence of an intermediate zone is inferred. This would be synchronous with an upward surge of the rock magmas slowly ascending. The rising temperature will cause an inversion of that normal order of deposition of the different metals that takes place ordinarily by falling temperature. As examples of this are given Aspen, Colorado, and Tiro General, Mexico.

Georgetown, Colorado, veins which show a lining of quartz crystals and a central mass of sphalerite and galena are explained as follows:

"The fissures were filled by injection by a highly concentrated galena-blende magma. The first precipitation was of quartz deposited before the cooling had progressed to the stage necessary for the crystallization of blende and galena."

Ore magmas may form banded veins. In many veins gold appears near the walls; Spurr has this explanation: "I suggest the action of differential gaseous tension, the metallic elements having, as I assume, a higher gaseous tension than silica."

Wavy, banded structure in veindikes is said to be usually not due to gradual filling but "indicates a pulsating deposition from a standing solution (ore magma?) which filled the fissure."

Inclusions of country rock in veins were suspended in the thick, viscous ore magma and frequently have been carried far upward in the veins. As inclusions are common in all classes of veins, it follows that the wavy, banded veins just referred to were also consolidated from a thick viscous solution. The veindikes have made room for themselves by their inherent "telluric pressure."

Contact metamorphism as usually defined is a misleading term. The ores in metamorphosed limestone have not been derived from adjacent or upper parts of the intrusive, but have ascended as ore magmas from the same deep chambers where all ore magmas originated.

The "zonal theory" of Spurr is based on the supposed vertical succession of metals in ore deposits, usually as follows: 1, tin, tungsten, molybdenum; 2, gold; 3, copper; 4, pyrite and arsenopyrite; 5, zinc; 6, lead; 7, silver. This indicates deposition during gradually lowering temperature. A reversal of sequence is obtained by deposition during a stage of rising temperature due to slow upward migration of heat. This closes the presentation of Spurr's views.

Fundamentally, these do not differ so greatly from those of other "magmatic" geologists. I quote, for instance, with hearty approval, this sentence in his first paper[18] in *Economic Geology:*

"This theory proposes that metalliferous fluids, from which most ore deposits are precipitated, are extreme differentiation phases of rock magmas; that most ore deposits and 'mineral veins,' as a class, represent one or the other of the extreme products of magmatic differentiation; and that the most striking chemical differences between ore deposits is due (in the more important class representing the siliceous extreme) to the successive precipitation in theoretically vertical zones, as the fluid migrates toward the surface, and with diminishing heat achieves more and more mature crystallization."

[18] J. E. Spurr: *Economic Geology*, 1907, p. 795.

THE MAGMA

Magma has a definite meaning. The derivation is from a Greek word signifying a soft or doughy substance. It is used to designate the material from which all our igneous rocks have consolidated. A simple melt of an igneous rock would not ordinarily be a magma, for the volatile constituents, such as water, sulphur, chlorine, fluorine, and certain amounts of metals entrained made their escape when this igneous rock congealed. It is assumed that large amounts of magma still exist in actual or potential fusion in the crust of the earth.

All the magmas we know are silicate melts with more or less volatile constituents. There may be other worlds where the magmas, the lava flows, and the intrusions consist chiefly of iron, nickel, gold, platinum, or sulphides. With some stretch of the imagination we may even picture a world in which the magma consists of colloidal gel. But for our earthly purpose we can only define *magma* as a liquid of high temperature that consists of a mutual solution of complex silicates, at times with admixed oxides, and always containing a certain amount of dissolved volatile material. Logical usage demands that the term "magma" be restricted to the above definition.

Isolated parts of the magma such as the gases, or the metallic oxides, or the silica cannot be called a magma and not even an "ore magma." When differentiation has proceeded to a point where only one component or several similar components remain, the term magma should be dropped. One may properly speak of quartz or iron ores, sulphides or gases *of magmatic origin.* It should be obvious that you cannot take a complex whole, cut it up in its integral parts and still apply the same name to the parts as to the whole. The pegmatites are derived from a complex silicate melt and a volatile component, and would, therefore, still logically be considered as congealed from a magma. A basic rock with more or less sulphides, such as that from Maine, described by Bastin, may also be said to have solidified from a magma.

It is very difficult to ascertain the composition of Spurr's ore magma. From a close analysis of Spurr's writings it would seem that it is a viscous melt containing useful metals, but frequently it takes the form of a gel—a silica gel or a carbonate gel (if such a thing has permanent existence in nature). On the other hand, evidently a liquid must be extraordinarily tenuous if it can penetrate and replace all rocks without phenomena of filling. About replacement deposits the following is asserted: "Many veins have been formed by replacement or impregnation along fractures, indicating a thinner and more aqueous ore magma." It is evident, therefore, that any vein-forming solution is an ore magma.

Although the writer freely recognizes that a magma may split up in many unlike parts, some of them containing useful metals, he feels obliged to reject the term *"ore magma"* for the latter products.

What causes the volatile constituents and the silica to separate from the parent magma? Apparently the most general reason given is the crystallization induced

by cooling. P. Niggli has given the best treatment of this process. The salic extracts are first separated with initial increase of pressure. Later the hydrothermal solutions escape with gradual lowering of pressure[19]. Obviously, however, a similar escape of volatile substance must result if a magma without crystallizing is gradually forced up to higher levels. Finally, as the magma rises to the surface, emanations are separated from it in the form of complex volatile substances, but which rarely are sufficiently concentrated in proper channels to form ore deposits.

It follows then that the differentiation of the volatile part is a process beginning at great depths and not ended till the final congealing at the surface. In abyssal depth, where the magma has remained long in equilibrium, no crystallization takes place and no emanations are given off. The equilibrium must be disturbed before separation can take place. Most, though by no means all, of this differentiation the writer holds takes place near the apexes of stocks and batholiths.

DIKES

During igneous intrusions and flowage, tabular masses of magma are frequently injected in the surrounding rocks. These we call dikes. Conceivably the rocks may be sundered by tension and the magma would fill the open tension crack. Usually, however, the space is opened by the hydrostatic pressure of the magma aided by the tension of the gases contained. The magma forces the dike walls apart. The magma fills the space created. While fluid it may surge upward to the end of the dike; it may even overflow; but when equilibrium is attained, the freezing begins rapidly and the dike is soon a massive, homogeneous rock. Where the walls are cool, the chilled border may be finer grained or otherwise slightly different. There is no banding; substantially the rock is homogeneous. The volatile substances have escaped upward or sideways through the walls; if present in abundance, contact metamorphism may be evident close to the walls. Lime silicates and iron silicates and ore may form in limestones to a limited extent. The writer is sure that such dikes are not uncommon.

PEGMATITE DIKES

Most of us probably agree that the pegmatites with their coarse texture and often complex composition have congealed from a magma that had already undergone a considerable amount of differentiation. These products may be designated as salic extracts in which the silica, alumina, and alkalies have been greatly concentrated. They are often called the residual juices of granitic rocks, separating or being squeezed out as the crystallization begins throughout the rock. The silica entrains many of the common and rare metals such as tin, tungsten, and molybdenum, and the rare earths are carried along probably by mineralizing agents, for phosphorus, boron, fluorine, and chlorine are present in many of the dikes. However, the sulphides are poorly represented, except in some varieties which carry bornite and chalcocite; gold is rare or present in traces only.

It is assumed by some that the pegmatite magma contained much water; others believe it contained but little. At any rate, the magma was surely very fluid; the melting points of the silica and silicates had been greatly lowered; the gases contained—or liquids above the critical point—frequently penetrate the wall rocks, causing deposition of high-temperature minerals, such as tourmaline or other products of contact metamorphism. The rare minerals (such as tourmaline and beryl) formed at a somewhat later and cooler stage; extensive replacements occurred, as of albite after orthoclase[20], and as still later products we find zeolite, fluorcarbonates, and carbonates.

The life story of a pegmatite dike is sometimes complex, but it is certain that the great majority of such dikes are compact, simple, and contain few rare minerals. Such druse minerals and replacements may have been formed rather by residual liquids still contained in the dike than by new supplies of magmatic juice of different composition from that of the original dike material. Schaller, and others as well, think they result from replacement by later ascending hydrothermal solutions.

Like Spurr, the writer feels sure that the pressure of the magma opened the dike fissures. Evidence of its comparatively great mobility is afforded by the intimate pegmatitization of many rocks.

According to Spurr, the pegmatites form direct transitions into gold-bearing quartz veins. Therefore, he says, they came from the very deep magma basins where differentiation has been going on for eons in slowly cooling magmas. The writer would like to present the slightly different version that pegmatites are a normal accompaniment of the consolidation of acidic rocks whether abyssal or intrusive near the surface. We find them, for instance, abundantly in the deep Archean of Canada and at the apexes of batholiths reaching within a few thousand feet of the surface. Therefore, they are a phenomenon of normal cooling, not of abyssal differentiation.

Another feature indicating fluidity of the pegmatite magma is seen in the not uncommon banding. This banding is coarse, never fine. Occasionally, one may observe sheaves of muscovite along the walls, then large orthoclase crystals, and lastly a central filling of pure quartz, sometimes projecting in drusy cavities.

The temperature of the beginning of the separation of the druse minerals (such as tourmaline) may be confidently put at about 575 deg. C.; the earlier temperatures may have been much higher; the final temperatures were 200 deg. or 300 deg. lower than 575 deg., which represents the inversion point of quartz. The pressure differed greatly; in the Kristiania region, according to Brögger and Goldschmidt, it probably did not exceed 400 at. In abyssal pegmatites it was certainly much higher.

RELATION OF PEGMATITE DIKES AND VEINS

It is recognized, and fully in agreement with Spurr in this respect, that pegmatite dikes may form transitions into barren quartz dikes and that many gold and tin veins show a close relationship to the pegmatites, but the writer is inclined to think that actual transitions are very rare. At least he has seen none that could be properly so termed. Some of these veins are evidently directly derived from intrusives by differentiation, and so are the corresponding pegmatites, but the differentiations seem to belong to two separate, successive stages. In few places is this better illustrated

[19] P. Niggli: *Abhandl. z. prakt. Geol.*, Vol. 1, 1925, pp. 1-69.

[20] W. T. Schaller: *American Journal of Science* (5), Vol. 10, 1925, pp. 269-279.

than in Reuning's[21] description of the Natas mine, in German southwest Africa. Here is the apex of a small batholith intruded in schists. From the apex radiate many typical pegmatite dikes, some of them with a little gold, scheelite, and copper ores. There are also later and much longer quartz veins of what is called hydrothermal type, which also carry the same two minerals. No doubt these veins are true exudation products of the magma. Clearly we have here two stages: 1, the pegmatite stage, and, 2, the hydrothermal stage, the latter containing much less alumina and more water than the first.

Spurr speaks of the close relationship of the California gold-quartz veins with pegmatites as shown by the common presence of albite, but he must be aware that the albite here simply means that the country rock was rich in sodium and that this albite cannot be regarded as of magmatic origin. The albite develops by preference in the altered country rock at the Utica mine, Calaveras County, Calif., at the Eagle Creek mines, Alaska, and at Kalgoorlie, and in all places it can be shown that it only appears in force when the country rock is unusually rich in sodium.

The case is similar to the adularia which often develops in epithermal veins in country rock rich in potassium, as at Cripple Creek, at Tonopah, at Silver City, Idaho, and many other places. It does not mean in the least that this vein material is a pegmatite. It is not a magmatic phenomenon at all. It simply forms instead of sericite under certain conditions, the reasons for which we do not yet quite understand. Spurr's conceptions of the California gold-quartz veins are somewhat curious. He says, for instance,[22] that the quartz does not penetrate or silicify the country rock; therefore, it must have been deposited by dry ore magmas: in the country rock the alteration is to iron carbonate. It is general knowledge that the alteration of the country rock is intense and in places, as along the Mother Lode, very extensive. Also that siderite is not one of the alteration products, only mixed ankerite-carbonates, or calcite, with a great deal of sericite, which indicates strong hydration of the country rock from the vein-forming solutions.

The Fissures

The question of how the vein fissures were formed and filled has been debated for at least a hundred years, and we are apparently yet far from a unanimous opinion. Fissures may be formed by compressive or by tensional stresses. If the former, the conditions for open spaces to be filled are more unfavorable. On the other hand, tensional stresses will tend to preserve open spaces along the fissure. The writer believes now that fissures frequently result from tension. Even under these conditions the fissure will tend to close under the influence of rock pressure, though less rapidly.

Actually we find that a large number of deposits have originated entirely by replacement, evidently along tight fracture zones, only penetrable by very mobile solutions. In other places we find the strongest kind of evidence of filling of open spaces. It seems that open spaces may well exist to a depth of many thousand feet. Large open cavities are often found in veins. Old mine workings and stopes may often remain open for a long time. Any mining engineer has seen enough examples of this. Take the case of the Alpine mineral fissures[23]. Although they were formed at great depth, and often carry high-temperature minerals, these flat veins are still open in part perhaps for 10 to 20 m., and for much greater distance before being filled. And the case for the filling is, evidently, perfect in this class of veins. In abyssal depths, fissures will not remain open unless strongly supported. In Scandinavia, for instance, where the Archean was deeply buried, there are very few examples of filled veins.

The Filling

When the fissures were open they were filled with solutions. These solutions may have been under a very heavy hydrostatic pressure if they communicated with the surface, say 30 at. per 1,000 ft. If the solutions emanated from a magmatic source but did not connect with the surface the pressure may have been several hundred atmospheres, not enough perhaps to break through the crust, but sufficient to counteract materially the closing tendency of the walls. The net pressure would create near-surface conditions, and everyone knows that in epithermal veins abundant open cavities did exist.

Even when openings did connect with the surface they might have been so limited as to produce a throttling of the magmatic gases or liquids and long-continued heavy pressure.

The writer therefore fully agrees with Spurr's view that the fissures were held open, in some deposits, by internal pressure which continued in the main until the fissure was filled; but disagrees with him as to the mode of filling.

Spurr's typical "ore magma" for the gold-quartz veins is apparently a gel containing about 14 per cent SiO_2 and 86 per cent H_2O. Such gels have been made, but they are very unstable. Ordinary gels contain more nearly 3 per cent or 4 per cent SiO_2. When we further consider the hydration of the country rock by the development of sericite, this would still further increase the water in the ore magma, and the usually abundant CO_2 as indicated by carbonization would still further augment the fluidity. So we see that on Spurr's own data the "ore magma" would be pretty tenuous, though probably gelatinous enough to interfere with free crystallization. We would expect to find, as the result of crystallization, a maze of doubly terminated quartz crystals; this is just what we do not find, but rather crystals attached to walls and inclusions. The crystallization would leave the "veindike" as a mass of loose crystals; it is, therefore, necessary to have new supplies of "ore magma" constantly ascending in order to create a filled vein. His conception, therefore, in reality differs but little from the old views of gradual deposition by mobile solutions.

Other "veindikes," like those of Georgetown, Colo., are described as being filled by the injection of a highly concentrated galena-blende magma. Just what is meant by this is difficult to interpret. From other passages it may mean a mixed gel of silica and sulphides. From this mixture the silica *diffused* (!) to the walls, there to crystallize in comb-form while the colloidal galena-blende filled the center. Even if concentrated, this sulphide gel could only have contained a few per cent of

[21] E. Reuning: *Neu. Jhr. f. Min., Geol. u. Pal. Beilage* 52, A., 1925, pp. 192-264.
[22] J. E. Spurr: The Ore Magmas, 1923, p. 523.
[23] J. Königsberger: *Neu. Jhr. f. Min. Geol. u. Pal. Beilage*, 14, 1901, pp. 43-49.

sulphides, and how to get the solid filling without a continuous supply of more silica-sulphide gel continually welling up from the depths remains a mystery.

The banded epithermal veins are indeed a great cause of annoyance to Spurr, but when he suggests that this banding is not due to gradual filling but to a rhythmic, pulsating deposition from a standing solution which filled the fissure, then the critic is reduced helplessly to asking how it is possible the fissure will be *filled* from this standing ore magma. One may conceive a gel crystallizing with strong contraction to chalcedony or to more coarsely crystalline quartz; likewise one may conceive diffusion banding created in the gel by reactions between electrolytes. It is needless to add that this banding is not the kind characteristic of banded epithermal veins.

The Camp Bird vein is a case in point. The excellent plates of Ransome[24] so convincingly show the gradual, in part colloidal, deposition from moving solutions that no further argument is necessary.

The writer feels compelled to place in the same categories the statement about the "pyrite-carbonate gels" ("The Ore Magmas," p. 141) and the "earthy-gangue veins" (p. 794) which have not been deposited by water but have been intruded as jellies or gels. No physical chemist has yet been able to produce a stable carbonate gel. In the face of great difficulties the Cobalt, Ontario, veins are also unhesitatingly declared to be of intrusive origin.

However, ordinary *filling*, whether by Spurr's or any other theory, is not the only way in which the "filled veins" have been accounted for. A fairly large contingent, represented by Stilwell[25] and Howe[26], working respectively in Victoria, Australia, and California, assert that what Spurr and many others, among them the writer, call by that name is simply replacement in quartz, replacing country rock. The field relations alone speak loudly against such a view; it is not necessary to enlarge upon this; the inspection of photographs representing the veins of Bendigo, Ballarat, and California suffice to make it plain. Frankly, the writer cannot accept a theory of replacement for these veins as far as the quartz is concerned.

Replacement there is, and plenty of it, but it is of a different kind, involving carbonization, sericitization (with hydration), and, in places, albitization. This proposition is advanced with considerable confidence: That aluminous rocks (shales, schists, and igneous rocks) cannot be replaced by coarse-grained quartz without leaving abundant traces by structure, texture, and relics. A quartz replacement of an aluminous rock can always, I believe, evidently, be easily identified as such. Until this proposition is proved wrong, the writer will not further enlarge on the subject. A few years ago he ventured to publish a note[27] which seemed to present conclusive evidence of quartz filling based on a specimen from Bendigo.

There is also another clan which places strong faith in the linear force of growing crystals and the ability of this growth to push vein walls apart and thus make room for the vein filling. Recently, Taber[28] has been the most prominent champion of this view, but there are many others apparently overlooked by Taber. The originator of this theory seems to have been von Weissenbach, about 1836. Bischof, Volger, and others had similar views. In fact, the latter investigator[29] experimented with copper sulphate and showed how fibrous veins of this material were able to break earthen vessels. Recently, Boydell[30] has discussed this problem from several viewpoints. The writer fully agrees with his views and believes that this force is a negligible factor as far as the opening of veins under heavy pressure is concerned, but that it is probably of some importance in effecting changes and movements in the opened fissure.

Some years ago W. Bornhardt[31] described in great detail the remarkable probably mesothermal vein system of Siegen, Rhenish Prussia, and presented a wonderful series of colored photographs of the veins. He came to the conclusion that the fissures were opened by "internal pressure," but left undecided whether this was caused by crystal growth or by pressure of the solutions. In an appendix, P. Kruch states that he can find no evidence of pressure in the structure of the crystals except very locally, in the veins. Both men appear to lean toward the latter alternative.

"ORE MAGMAS" AND "VEINDIKES"

In a previous paragraph the objections to the term "ore magma" were stated. According to Spurr the product of solidification of the "ore magma" is a "veindike." All ore deposits connected with magmatic emanations (except cinnabar and stibnite deposits) are evidently "veindikes." A careful study of Spurr's writings can lead to no other conclusion. The "ore magma" is differentiated from the parent magma, injected, consolidated. Nothing could be more simple.

Replacement, or metasomatism, is an awkward fact to face in this theory, and Spurr touches lightly on it. But this much seems clear—that he regards pure replacement deposits like that of the United Verde mine, in Arizona, as "veindikes."

Some magmas or fluids of magmatic origin may fill fissures close to the original source without appreciable metasomatism. If it is desired to call these deposits veindikes, well and good. But in practically all ore deposits replacement of the wall rock plays a part as important, or more so, than the process of filling. Take the case of the United Verde: this gigantic ore pipe, with diameter of 500 ft., is entirely a product of replacement.

From the moment that the magmatic emanations attack the country rock an exchange of constituents begins. The "ore magma" is an ore magma no longer; it is a mixed product of emanations and material such as silica, sodium, potassium, magnesium, and calcium, abstracted from the rock, be this part of the batholith or adjoining rock. Usually a little more is added than abstracted, say on the order of 200 to 300 kg. per cubic meter. For the constituents lost, carbon dioxide, sulphur, iron, copper, and other substances have been added. It is not difficult to realize that after the solutions have ascended the fissure a short distance the so-called ore magma loses its magmatic nature in great part. Besides, water is undoubtedly acquired, especially

[24] F. L. Ransome: U. S. Geological Survey Bull. 180, 1901, pl. XI, XII.
[25] F. L. Stillwell: *Economic Geology*, Vol. 13, 1918, pp. 100-111.
[26] E. Howe: *Economic Geology*, Vol. 19, 1924, pp. 595-619.
[27] W. Lindgren: *Economic Geology*, Vol. 15, 1920, pp. 312-314.
[28] S. Taber: *Trans.* A.I.M.E., Vol. 61, 1919; *American Journal of Science* (4), Vol. 41, 1916, pp. 532-556.
[29] Volger: Pogg. Ann., Vol. 93, 1854, p. 224.
[30] H. C. Boydell: *Economic Geology*, Vol. 21, 1926, pp. 1-56.
[31] W. Bornhardt: Uber die Gang Verhöltnisse des Sieger Landes. Archio f. Lagerstatten forschung. Kgl Preuss. Landesanstalt, Berlin. Two volumes, 1912; appendix by P. Krusch.

when the solutions ascend in the rocks surrounding the intrusive. The writer has a strong conviction that much of the barren material deposited in the upper parts of the vein is simply derived from the country rock lower down. Of course, when the whole deposit is of the replacement type, the change in the nature of the solutions is correspondingly rapid.

Let us see what happened in case of some Bolivian tin veins that Spurr includes among the "veindikes." At Caracoles[32] the veins are of the hypothermal[33] type and are formed entirely by replacement. There is no filling to speak of. The solutions must have been very mobile to penetrate the tight fissures and adjoining rock; they must have ascended from the lower part of the granite batholith into the upper cooler and congealed portion. They contained much water, as chlorite and sericite are among the chief metasomatic products. They were loaded with iron, tin, boron, magnesia, and some sulphur. They abstracted sodium, potassium, and calcium to the extent of 200 kg. per cubic meter from the slightly altered country rock. From the vein itself much larger amounts per cubic meter must have been extracted. To call such solutions ore magmas is surely to convey an erroneous impression.

The veins at Chocaya afford another example. Here the tin veins are of the epithermal type and have formed in acidic flow rocks. Here we find pyritic and sericitic alteration of the country rock, but there is no ore in it. The vein is a beautiful example of a filled cavity; in places full of touching fragments of country rock (bubbles), which are coated with pyrite, quartz, and cassiterite in thin colloidal layers repeated three times. Later follows chalcopyrite (oldest), stannite, tetrahedrite, chalcopyrite, and jamesonite as successive wavy bands filling the fissure. The succession is the same as at Potosi. The open fissure has been gradually filled.

All this will make clear my reasons for rejecting the terms "ore magmas" and "veindikes," except as they may refer to certain pegmatite dikes and some very closely allied forms of quartz veins.

The Inclusions

Since 1836, when von Weissenbach described and figured the Saxon deposits, the inclusions found in fissure veins have attracted the attention of observers. Many of the older writers of textbooks (Stelzner, Posepny, Beck) call attention to the loose, partly filled rubble of inclusions of country rock that locally fill many veins, and describe the partical coating of these fragments by gangue and ore. Frequently these inclusions appear to be swimming, unsupported, in the vein filling. Attempted explanations of this phenomenon are numerous. The first suggestion would be that the local vein section is deceptive; that the fragments seem unsupported, but really touch at points beyond the section. Experiments have been made to test this by pouring fluid cement into a box of such loose rubble, and preparing sections after hardening. Such sections actually show many unsupported fragments.[34]

Still others maintain that the inclusions have been separated from the walls by the "force of growing crystals"; others again that they are remnants of country rock which have escaped the general replacement in the vein. Spurr believes that the inclusions are supported by the viscous "ore magma," and thinks that they may have been brought up by this "magma" from indefinite depths. He even goes so far as to state that the presence of unsupported inclusions is a proof that the vein was congealed from the "magma."

Any of these explanations may be applicable. Surely the crystallizing gangue often detaches fragments from the walls; such results are often apparent in the Cobalt veins. In these veins which are closely related to the pegmatites the solutions may be able to support fragments. No one may doubt that residuals after replacement may closely simulate inclusions.[35] But, as the writer believes that the crystallization of the vein matter proceeds generally from solutions of no great viscosity and is a gradual affair in the rising fluids, it seems clear that an important factor is the constant dropping off of fragments from the walls. These fragments will be caught and supported by the vein material in process of formation.[36] Frequently the writer has observed inclusions of wall rocks coated by a loose comb of quartz crystals or incrusted by a shell of rich ore minerals. This recalls the "cockade ore" in which the inclusion is partly replaced and surrounded by rings of successively deposited sulphides. Fine examples of this occur in the Alice mine, Butte, where these inclusions in part are made up of older pyrite-sphalerite and where they are contained in a drusy matrix of rhodonite, rhodochrosite, and quartz.

That the vein solutions have carried up fragments from great depths does not appear demonstrated. Howe[37] states that in the Grass Valley veins the intersections of contacts by the veins are marked by a change in the character of the inclusions. The case from the Camp Bird vein mentioned by Purington and cited by Spurr[38] is not convincing, for it is evident that the flow rocks, which here constitute the walls, may have carried up fragments from deeply buried sediments and that such fragments may have been detached during the vein formation.

The Ore Zones

Vertical Succession

The question of ore zones, or the vertical succession of certain metals and minerals in ore deposits, is of great interest and importance. Many of the fundamental facts have long been known. Most familiar is the example of Cornwall tin veins, which carry copper ores in their upper parts, in the slates, presumably cooler ground. That lead ores do not always continue in depth, but are replaced by pyrite, sphalerite, and siderite, is also well known. Other examples, at Bingham for instance, show veins that in the unaltered limestone carry mainly lead and zinc, but go over into copper ores within a vertical distance of 1,000 ft., while the quartz-calcite gangue changes more or less to lime silicates.

A case has been described by Spurr[39] from Peñoles, Mexico, where the veins present a continuous deposition from the high-temperature stage to the stage of the rich silver ores, and finally to the last deposits of nearly barren gangue minerals. Many gold-quartz veins con-

[32] W. Lindgren: *Economic Geology*, 1926, in press.
[33] The word hypothermal of course involves no commitment as to the source of the hot water. Most of it probably came from the magma, but the word itself implies nothing but an aqueous solution of high temperature.
[34] W. Bornhard: *Op. cit.*, p. 229.
[35] A. M. Bateman: *Economic Geology*, Vol. 19, 1924, pp. 504-520.
[36] This explanation, long in mind, was recently advocated by J. W. Young in a letter to the *Engineering and Mining Journal-Press*, Oct. 13, 1923.
[37] E. Howe: *Economic Geology*, Vol. 23, p. 613.
[38] J. E. Spurr: *Economic Geology*, Vol. 20, 1925, p. 136.
[39] J. E. Spurr: The Ore Magmas, 1923, Vol. 1, p. 52.

tinue without much change for 4,000 or even 6,000 ft. of vertical depth. Evidently the problem is complicated and one in which exceptions and reversals are plentiful. Generally speaking, the high-temperature veins are likely to carry tin, tungsten, copper, and zinc. But, on the other hand, the Broken Hill lode (New South Wales) is one of the world's greatest lead deposits, though undoubtedly formed at high temperature.

Gradual lowering (or increase) of temperature is the universal explanation offered by Spurr, who gives the following theoretical vertical succession brought about by lowering of temperature. Deepest: *A*, tin, tungsten, molybdenum; *B*, gold; *C*, copper; *D*, pyrite, arsenopyrite (auriferous and argentiferous); *E*, zinc; *F*, lead; *G*, silver. The first two divisions are said to be connected with coarse-grained rocks; the second and third with fine-grained holocrystalline rocks; the last three with fine-grained porphyritic rocks.[40] This latter coordination scarcely seems intelligible. A gradually increasing temperature brings about a reversion in the order; thus, at Aspen, polybasite is said to be followed by galena and that by zinc blende. In the epithermal (near-surface) veins the deposition is stated to proceed under rising temperatures, and, according to Spurr, the whole succession comes down quickly, superimposed and without order.

Undoubtedly this idea of "telescoping deposition" and reversal in order is a good one, but it would seem to be far more easily applicable to a gradual deposition by solutions than to a thick, viscous congealing "ore magma."

The order of deposition is not simply a function of temperature. The precipitation is a function of temperature, pressure, time, concentration, and accompanying components in the system. Therefore any *dictum ex cathedra* regarding the succession in vertical zones will be difficult or even impossible. Cassiterite is generally a high-temperature mineral, but it may be abundantly deposited in mesothermal (Potosi, Bolivia), or epithermal veins (Chocaya, Bolivia); molybdenite is normally a high-temperature mineral, but it is present in finely divided form in the Cripple Creek veins, which are also epithermal. This does not indicate any reversal, simply that the initial temperatures were higher than those of the main deposition.

The data of vertical succession are in part obscure and contradictory; the main known features have been set forth by Spurr and also, lately, by W. H. Emmons,[41] who has devoted an important paper to this subject. The great vertical range of the mesothermal and hypothermal gold-quartz veins stands out prominently, contrasted with the short range of the epithermal gold-silver veins. Other things are more doubtful. Why are copper ores followed upward by zinc and lead, whereas usually zinc separates out before rather than after copper?

Succession in the Same Ore

Another closely related and interesting subject is the succession of minerals in the same ore. In all deposits of magmatic affiliation, from contact metamorphic ores to those of the epithermal veins, the same general succession holds, and the later minerals invariably replace the earlier ones. Not all of the minerals, of course, are present in the same ore, but, broadly speaking, this succession holds (beginning with the older): silicates, quartz, carbonates, and other gangue minerals (sometimes overlapping and repeated), magnetite, specularite, pyrite, arsenopyrite (with Ni and Co arsenides), wolframite, cassiterite, molybdenite, bismuth, bismuthinite, pyrrhotite, pentlandite, stannite, sphalerite, enargite, tennantite, tetrahedrite, chalcopyrite, bornite, galena, chalcocite, carbonates, argentite, ruby silver, polybasite, chalcopyrite, electrum, lead sulphantimonides, carbonates, calcite. In general sphalerite antedates the copper minerals.

The position of gold is not constant; usually it is late in the series and may be accompanied by tellurides. The succession is in places reversed or changed. Magnetite may follow pyrite and sphalerite may follow galena; sometimes pyrite and marcasite are repeated. Spurr believes this indicates rising temperature; it may be so, but this simple explanation is probably not the only solution of the problem. The development of almost any kind of ore, then, involves a complex but orderly and far-reaching series of replacements. The writer submits the belief that a thick and viscous "ore magma" is incapable of effecting these replacements.

Temperatures of Deposition

Spurr advances an explanation for the great richness of the bonanza ores in the epithermal veins: they are derived from the same abyssal magma zone as the rest of the "ore magma," but they are deposited under conditions of increasing temperature as the lavas and the "ore magmas" rise to the surface. Aside from many other objections to this, the succession of minerals in the ores from these bonanza zones is substantially the same as for all other ores, and they would, therefore, seem to be formed under decreasing temperature.

Compelled by overwhelming evidence, Spurr admits that cinnabar and stibnite may form from hot-spring waters, close to the surface. But at many places (National, Nevada, and other districts) these veins pass into gold and silver veins. Moreover, neither mineral is confined to the epithermal veins.

Recent statements by Spurr[42] indicate that he believes that all ore deposits of magmatic affiliations have been deposited at minimum temperatures of 365 deg. C. and ordinarily about 400 deg. to 500 deg. C. No elaborate attempt will be made here to refute this view; but if this were correct, all deposits in limestone would have a gangue of lime-iron silicates. Ore deposits, the writer maintains, develop during subsiding temperature and may well be formed at temperatures of 100 deg. to 150 deg. C.

The next great task for the geochemists is to explain this remarkable general succession, which, as stated, broadly holds for all deposits ranging from pyrometasomatic to epithermal. A. C. Spencer has attempted to explain it for the deposits at Ely; great credit to him for this, though his solution cannot be considered final. It would seem that temperature is the most important factor; certainly it is not the only one.

Contact Metamorphism (Pyrometasomatism)

The manifestations of contact metamorphism, meaning thereby the replacements and crystallizations induced in sediments or similar susceptible rocks at intrusive contacts, are so well known and have been described so fully that it is not necessary to enter in details. All observers agree that the alteration of clay shales to hornfels and of limestones to silicate rocks are

[40] J. E. Spurr: *Op. cit.*, p. 18.
[41] W. H. Emmons: *Trans.* A.I.M.E., Vol. 70, 1924, pp. 964-994.
[42] Bulletin Geological Society of America, pp. 545-582.

the result of igneous emanations at first more aqueous, later more diversified. At the first contact the processes begin and reach their peak when the intrusive solidifies. The strongest action was produced when the rock at the contact had solidified and the interior was in the process of congealing. The common distribution of tourmaline, scapolite, and pyrite, sometimes far from the contact, indicates how widely the adjacent rocks were permeated by the hot fluids, for these minerals contain mineralizers like boron, chlorine, and sulphur.

The introduction of iron and silica in garnet, wollastonite, epidote, and hedenbergite is so common that it scarcely needs further emphasis. It is also extremely common to find copper, zinc, and lead minerals scattered in the lime-iron silicates and slightly later than these, often simply scattered, often in large masses of economic importance.

Spurr doubts the existence of "contact metamorphic" deposits. To his mind such ores are simply deposited by "ore magmas" rising on or near the contact from the deep manufactories of such "magmas." Every little contact metamorphic deposit is connected with the depths.

Undoubtedly veins exist that have been formed in limestone by deep-seated emanations. The writer has seen many of them; Spurr has described fine instances from Mexico. The only condition needed is that the temperature shall have exceeded say 500 deg. C., below which limit the lime silicates can no longer form.

But the writer has also seen so many instances where no such deep-seated fissures can be postulated, that it seems absurd to deny the actuality of emanations from adjacent intrusions. The localizing of such deposits at limestone inclusions and projecting points can hardly be explained always by convenient deep vents of "ore magmas." The writer cannot understand how anyone who has read Harry Eckermann's[45] important work on the contact metamorphism of inclusions can explain these facts in any other way but by emanations from crystallizing magma. Sometimes, as at White Knob, Idaho, the alteration has gone so far that limestone and igneous rock can no longer be sharply differentiated. Why call on abyssal sources when conditions at the top, or apex, of any batholith are well known to be most favorable for the collection of liquid and gaseous emanations?

The admirable map of Copper Mountain by C. W. Wright[46] offers the writer convincing proof of his views. Here the upper part of a batholith is several miles in diameter. At every place where limestone is at the contact there is contact metamorphism, and at close intervals all along these parts of the contact the copper deposits are located within the narrow strip of silicate rocks. Did Nature provide a fissure or vent at each one of these deposits, connected with the mysterious depths whence the "ore magmas" came?

The gases, evidently, came from the congealing intrusive; not only from the immediate contact but from large volumes of magma adjoining it, laterally and in depth. In origin one cannot separate the calcium silicates, the iron silicates, and the suphides and oxides. Though appearing in orderly succession they all came from the same source.

CONCLUSIONS

This paper begins with a brief historical review of the magmatic theory which states that many ore deposits have been formed by magmatic emanations. A special review is given of the opinions of J. E. Spurr and his use of the terms "ore magmas" and "veindikes."

The term "ore magma" is examined and rejected except for special cases, for instance, a normal magma containing much sulphides and oxides, or pegmatite dikes rich in the same constituents. After a brief consideration of dikes in general, the pegmatite dikes are discussed; under circumstances they may carry ore minerals and sulphides, also a little gold, but there is no unbroken succession between pegmatites and gold-quartz veins or tin veins. The dikes were forced open by the pressure of the magma. The presence of albite and adularia in veins does not indicate a relationship to pegmatites.

The fissures of the hydrothermal series of emanations often contained open spaces, especially where broken open by tensional stresses. The hydrostatic pressure from the surface or the pressure of escaping emanations, or both, helped to hold them open. The linear force of growing crystals is not considered an important factor in vein formation, except for the detaching of fragments in the opened fissure. Fillings were deposited gradually by mobile solutions, not from thick and viscous fluids, though close to the magma the viscosity no doubt was higher than nearer to the surface.

It is asserted that normal, coarse-grained vein quartz cannot be formed by replacement of aluminous rocks. The great importance of replacement in vein formation is emphasized. It is stated that the emanations begin to change with their first contact with cooler rocks; that they are continually depositing their magmatic load and taking up large amounts of material from the country rock. The term "veindike" is rejected as misleading, except for certain pegmatite dikes and other exudation products of purely magmatic origin.

The view that inclusions of country rock in vein matter are carried up and supported by a viscous vein-forming "ore magma" seems improbable. The effects of the force of crystallization detach them from the walls or they fall into the fissure from shattered walls and are supported by the partly filled vein.

The so-called "zonal theory" is examined after a brief historical review. It is pointed out that the vertical succession, although true in a general way, presents many inconsistencies and reversals, which cannot always be explained on the supposition of an increasing temperature. Closely connected with this subject is the succession of minerals and the succession of replacements in the same ore. An attempt is made to give a general succession of this kind. It is shown that the problem really is very complex and that it can only be solved by the physical chemist. At any rate, a thick and viscous "ore magma" is not capable of producing this striking succession of replacements.

Contact metamorphism (pyrometasomatic ores) is asserted to be a universal phenomenon attending the solidification of magmas. Both lime-iron silicates and sulphides have this origin. It is not denied that emanations ascending in limestone from deep sources may produce similar effects. Copper Mountain, near Ketchikan, Alaska, substantiates the views given; also the metamorphism of limestone masses included in the igneous rock.

[45] Harry Eckermann: Geol. För. Stockholm, Vol. 45, 1923, pp. 465-536.

[46] C. W. Wright: U. S. Geological Survey, Professional Paper 87, 1915.

Magmas, Dikes, and Veins

By J. E. Spurr

AS THE preceding paper purports to be a critical review of my views and an exposition of those of the writer (Lindgren), and as his presentation of my views is erroneous and misleading, my own comment will appropriately be preceded by a statement as to what, essentially, these views are. I have put them in tabloid form in an editorial,[1] as follows:

"The origin of gold-quartz veins as a variation of pegmatites has been argued as far back as 1861 by Thomas Belt, the distinguished English mining engineer and naturalist, but the idea was ignored by geologists. These views were independently advanced by J. E. Spurr in 1898 as an explanation for the Yukon gold-quartz veins. This conception, however, was of highly heated water as the end product of granitic differentiation, this magmatic water being the ore solution. But in 1905, studying similar gold-quartz veins in Nevada, Spurr pictured the ore solution in this case as concentrated and the gold-quartz as intrusive, just as pegmatites are intrusive. In 1907 the Zonal Theory of Spurr showed the interrelation of the different metals. This theory postulated that in the final pegmatitic residue of a magma many metals are present, and that with decreasing temperature each is separately precipitated, the deep-seated gold-quartz ores representing one of the deepest zones, close to the pegmatites. This theory, now generally accepted, pictured at first the ore solutions essentially as magmatic waters, except in the case of certain gold-quartz veins and ore-bearing pegmatites. The Ore Magma Theory, proposed in 1923, substituted for magmatic waters, highly concentrated and dense magmatic residues; for long circulation, a definite stage of injection; for fissures already open, the forcing open of fissures in many cases by the ore magma; for slow accretion of precipitation, simple crystallization from the injected ore magma."

For a longer presentation, I refer the reader to my presidential address to the Society of Economic Geologists.[2] In this paper I sketched briefly the development of magmatic theories of ore deposition, from the time of Elie de Beaumont, in 1847 and Lyell in 1857, through to the revival of this school in the United States. I wrote:

"But directly after Posepny's paper, a young American school arose, which, making use of field observations and consequent inductive reasoning, worked essentially back to the school of de Beaumont and Lyell. . . . Of this school were Kemp, Weed, Lindgren, and myself, and, later, many others; and many important papers, which I will not try to enumerate, built up an impressive array of facts and conclusions. The source of mineralizing waters was more and more referred to the igneous magmas, as de Beaumont and others, including the Austrian geologist, Suess, had done; in other words, such waters were not conceived of as surface-derived or atmospheric water, but as largely new water, born from the crystallizing igneous rocks."

This school of thought I called the "hot-spring school," to separate it from the "lateral-secretion school," which latter was predominant in the United States in the early part of my professional career, and which still survives in the Mississippi Valley and elsewhere.

In outlining the progress away from these schools, to which I and other American geologists at one time fully subscribed, I observed in the above-mentioned address:

"The two opposing schools of thought, which we may call the lateral-secretion school and the hot-spring school, both ascribe the deposition of ores to the agency of circulating waters, whether atmospheric or juvenile. Sharply defined from both these opposing theories is the theory of magmatic differentiation, first proposed, so far as I know, by J. H. L. Vogt, of Christiania, in 1893. The idea of magmatic differentiation of rocks dates as far back as Scrope in 1825."

And on page 624:[3]

"Vogt explained certain ores as due to this process of magmation, therein, as I said before, establishing a markedly different new school of thought in the explanation of ore deposition. Instead of water, whether atmospheric or expelled from cooling magmas, as hot springs or fumaroles, Vogt appealed to the igneous magma itself as the carrier and the segregator of ores; and thus water and magma as agents of ore concentration are clearly set off from each other. The question then comes up: What is magma? We know it is the fluid from which igneous rocks crystallize; but we now recognize it as also the source of certain concentrations of metallic minerals; and it is also the source of much water and of gases of many kinds . . . The magmatic segregations of Vogt are evidently considered as dry segregations, since he eliminates gaseous agencies, the chief of which is water; and he admits as magmatic segregations almost exclusively ores connected with basic rocks, considering the ores as among the first minerals to crystallize — according to the petrographers' conclusions, arising from the frequently clean-cut or idiomorphic form of these ore minerals, where they occur in the igneous rocks; and considering that these earliest-formed minerals have migrated, by a process which he does not satisfactorily explain, so as to concentrate. My own views as a self-styled magmationist, therefore, find no support in the views of the founder of the magmationist school. While Vogt found his inspiration in the extremely basic rocks, I have always been fascinated by the extremely siliceous igneous rocks—granites, quartz-feldspar rocks or alaskites, pegmatites, quartz dikes, and related quartz veins. Certainly, however, these siliceous extremes are as truly magmatic as the basic extremes; and when we recall that even in granites it is universally acknowledged that water and other gases are essential magmatic ingredients, without which there would be no granite magma, it is realized that Vogt has erred in excluding the agency of gases from the processes of magmatic differentiation."[4]

My own chief contributions to advanced thought along these lines may be marked by three stages, which are concisely summarized in the editorial quoted in the beginning of my comment. These were the three stages: First, the gold-quartz-pegmatite theory, which was original, but in which I years afterward discovered that I had been forestalled by Thomas Belt in 1861, and by him alone; this theory involved the recognition that certain gold-quartz veins were transitional from pegmatites (1898) and that they crystallized not from gradual precipitation from circulating hot waters, but from a concentrated gold-quartz magma (1905), which played the rôle of an independent intrusion; second, the conception and announcement of the zonal theory in 1907, which was original with me and was elaborated upon repeatedly in subsequent years—this theory postulating that "in the residual magma from which, for example, pegmatites and later gold-quartz veins were formed, the other metals were also contained, and that these passed into the magma still residual from the consolidation of the gold-quartz vein, and were successively deposited each at a separate and critical temperature of freezing, with the result that the different metals were ideally deposited one above the other, or one outside the other, with falling tem-

[1] *Engineering and Mining Journal-Press*, Vol. 119, No. 22, p. 874, 1925.

[2] J. E. Spurr, *Economic Geology*, Vol. 18, 1923, p. 617.

[3] J. E. Spurr, *Op. cit.*, p. 624.

[4] J. E. Spurr, *Op.* cit., p. 626.

perature, and thus ores of copper, zinc, lead, silver, and other metals were successively deposited";[4] third, the ore magma theory (1923), which was radically different from all previous views, and which submitted evidence that not only gold-quartz veins and pegmatitic veins, but "many veins of copper, zinc, lead, and the like" have been "deposited from highly concentrated magmas, which appear in many cases to have intruded the rocks under pressure, much as does an igneous dike."[5] These relatively concentrated solutions I called *ore magmas*, dividing them into relatively dry and relatively aqueous classes. Yet even the aqueous ore magmas,

". . . according to my conclusions, are relatively highly concentrated metallic solutions, and are quite different from the mineralizing waters which I have hitherto pictured as the ore carriers in the case of copper, lead, zinc, and such metals."[7]

At the same time I proposed the name *veindike* for certain ore deposits:[8]

" . . . for those veins such as have been described by Belt, Vogt, and myself, as well as many others, which have been intruded as a thick magma, I propose the name veindikes, for all veins have not been so formed, some having originated from thinner although I believe generally highly concentrated solutions, and having been formed by replacement rather than intrusion."

I further stated that the ore magma of the dryer type "acts as an intrusive and forms a veindike, or copper vein, for example"; while the corresponding ore magma of the more aqueous type "acts more effectively by replacement and forms a replacement fissure vein, or an irregularly shaped replacement, or an impregnation or dissemination."[9]

These three stages of progress of my geological thought were revolutionary, and were not followed by my old associates of the "hot-water" school. The present widespread recognition of the applicability of these progressive discoveries, as I think I may call them, has come mainly from a larger group of geologists, scattered world-wide, and with great field experience. The significance of the intrusive nature of certain gold-quartz veins, which I explained in 1898, 1905, and subsequently, was not grasped by the "hot-water" school; the zonal theory of 1907 was regarded by some of this school as positively heretical in its unorthodox views; and although it was quietly assimilated, not until 1922 did it become current thought in the universities, due in considerable part to its recognition by Professors Kemp, Rastall, and Emmons in 1922-1924. The ore-magma theory, however, as expounded by myself in 1923 has had an immediate and world-wide assimilation, both with and without explicit recognition. Although of the old group of American "hot-water" geologists, of which I was also one, Lindgren has hitherto remained astonishingly immune from the influence of all these new ideas, as a study of his textbook shows.

Summary of Spurr's Views

With this necessary preliminary, I will take up some of the points which Lindgren makes in the paper to which this is contributed as discussion. His introduction and résumé of the development of thought among the geologists of the magmatic group calls for no particular comment, but his "Summary of Spurr's Views" calls for correction. He states that I believe that "the majority of ore deposits are termed veindikes . . . in fact it appears that all ore deposits, whether of replacement origin or not, are 'veindikes.'" This is quite erroneous (as is shown in the above quotations from my writings), and shows a decided confusion of thought. I have defined veindikes clearly enough, and often enough. Replacement deposits are not veindikes; even replacement fissure veins are not veindikes. An intrusive vein is a veindike. Otherwise this passage does not call for discussion at this time. He closes by saying that fundamentally my views do not differ so greatly from those of other "magmatic" geologists, and quotes with hearty approval a summary in my paper proposing the zonal theory in 1907. I am indeed glad to know that Lindgren now finds only minor points on which to disagree; nevertheless, his textbook, in this case, shows no connection with his present frame of mind.

The Magma

Now for the minor points of difference. He does not approve of the term "ore magma." He has printed this passage (headed The Magma) before, in the proceedings of the National Academy of Sciences, and I have already answered his objections.[10]

"Various distinguished geologists having attempted to define magma, with varying but on the average poor success, Prof. Waldemar Lindgren essays it in a paper read before the National Academy of Sciences.[11] He says:

" 'The word magma has a perfectly definite meaning. It describes a liquid of high temperature consisting of a solution of complex silicates in each other, perhaps with admixed oxides and always containing a certain quantity of dissolved volatile matter. . . . I submit that logical usage demands that the term "magma" be restricted to the above definition. . . . When differentiation has proceeded to the point where only one component or several similar components remain, the term magma should be dropped. One may properly speak of quartz, or iron ores, or gases *of magmatic origin*.'

"Considering this, the editor would first move to strike out the word *perfectly* as redundant and too jocund for the dignity of the National Academy of Sciences. It arouses the suspicion that Professor Lindgren may be spoofing, so that we examine the definition with greater care. Essentially, Professor Lindgren says a magma is a liquid. But at the high temperature which he mentions, it is universally acknowledged that the water or its components are gaseous, and that the other gaseous components are varied and important. Therefore *fluid* would be a more accurate term than *liquid*, since liquid is opposed to gaseous. Passing over the wonder why in the perfectly definite definition the 'admixed' oxides are prefaced by a 'perhaps,' one pauses at the dictum that the volatile matter is 'dissolved' in the silicates. Why not, the freshman inquires, vice versa: To wit, the silicates dissolved in the gases? Or why not the silicates and the gases in part coexisting and separate? Indeed, the ancient and modern conception of granite magmas at least—a conception the general truth of which is well founded—is that the granite magma remains fluid at comparatively low temperatures by virtue of the volatile constituents.

"Finally omitting various other reflections for the sake of brevity, Professor Lindgren would surely not, on second thought, insist on the last-but-one sentence quoted. He would grant, for example, that the fluid from which a pyroxenite has crystallized is a magma, although pyroxenite by definition consists of pyroxene; or dunite, which by definition consists of olivine; or anorthosite, which by definition consists of the feldspar labradorite; or albitite,

[4] *Op. cit.*, p. 628.
[5] *Op. cit.*, p. 631.
[7] *Op. cit.*, p. 632.
[8] *Op. cit.*, p. 631.
[9] *Op. cit.*, p. 632.

[10] J. E. Spurr: What Is a Magma? *Engineering and Mining Journal-Press*, Vol. 120, 1925, p. 562.
[11] National Academy of Sciences, Vol. II, No. 1, January, 1925.

which by definition consists of the feldspar albite; or many other rocks. Indeed, it is a matter of common nomenclature that a magma may yield one mineral almost exclusively, or be 'monomineralic.' Daly observes, for example, ('Igneous Rocks,' 1914, p. 447): 'The gravitative differentiation of anorthosite . . . implies the segregation, in depth, of the monomineralic dunite magma, the bimineralic wehrlite or harzburgitic magmas, or the trimineralic lherzolitic magma.' Professor Lindgren, now being supposed to retract his statement so far as it applies to monomineralic magmas crystallizing as olivine, or pyroxene or feldspar; should he be obstinate concerning a monomineralic magma crystallizing as quartz, claiming that it is no 'magma'? Quartz is as truly and as undisputed a magmatic mineral as the others in question. Pegmatites are referred to by Daly as crystallizing 'from gas-charged magma'[13] and Harker refers to pegmatites as representing, 'the final residual magma of plutonic intrusions,' and Lindgren himself says 'the pegmatites are essentially residual magmas,'[14] a slight carelessness of diction which we may overlook. Also he speaks of 'the transitions of pegmatite dikes to deep-seated ore-bearing veins.'[15] That a phase of pegmatite consists of pure quartz is universally acknowledged.

"Professor Lindgren also objects to the conception and term of a magma which crystallized as iron ores. Probably all authority and logic is opposed to him here. To quote from the handiest book for the moment, Daly refers[16] to titaniferous iron ores as 'obviously local differentiates of gabbroid magma,' and observes that "the sulphide ores of Sudbury are magmatic differentiates.' And Professor Lindgren himself, in a paper by Lindgren and Davey on the ores of Key West, Nev., describing nickel ores containing magnetite, pyrite, and chalcopyrite, writes of the metallic minerals, 'We believe that they have formed part of the magma of the dike and consolidated as the last of the minerals of igneous origin."[16]

"Indeed it would appear that Professor Lindgren's definition of a magma, instead of being 'perfectly definite,' is singularly inaccurate. The sharp line which he desires to draw between rocks containing metals in paying quantities (and therefore called 'ores') and those that may contain similar metals, but not in paying quantities (and therefore called simply 'rocks'), is properly a commercial distinction and not a scientific one. The term 'ore magma' introduced by Spurr is, as above shown, accurate; and, indeed, is so obvious that it can barely claim novelty."

This question of what to call the child is not essential; still, I feel that Lindgren is captious and that his position is untenable. Sir Thomas Holland, president of the Institution of Mining and Metallurgy, recently[17] referred to certain pyrite ores as crystallized from a "hydropyritic magma." The term "ore magma" doubtless will stick: it differentiates ore solutions sharply from hot waters, and so serves an essential purpose.

"It is very difficult," says Lindgren, "to ascertain the composition of Spurr's ore magma." It is indeed: I am still trying to get further light on this. It is also very difficult to ascertain the composition and condition of a rock magma. We should all investigate and study these problems patiently. Horace Freeman[18] has advanced an explanation which I am inclined to think throws light on the subject of ore magmas, but these magmas are evidently complex both as to composition and condition. Lindgren is perplexed because I described the ore magma as at times highly fluid and capable of replacement, and at other times gelatinous or viscous; but the same general observation is true of rock magmas and especially of pegmatite magmas. I may observe that first I divided magmas into three groups—rock magmas, pegmatite magmas, and ore magmas. Subsequent study led me to join the last two together—the ore magmas are, I believe, best conceived of as a phase of pegmatite magmas. If one would get my idea as to the nature of ore magmas, let him consider pegmatite magmas: every quality of the former is matched by the latter. The pegmatite-ore magmas (or pegmatore magmas, as I have called them) form in general a distinct group from the rock magmas, although there are transitional phases. Ordinary quartz-feldspar pegmatites, as it is well known, form dikes (veindikes), replacements, and disseminations, according to the variety. Ore magmas do the same.

[13]"Igneous Rocks and Their Origin," 1914, p. 368.
[14]Mineral Deposits, 1919, p. 762.
[15]Mineral Deposits, 1919, p. 761.
[16]Igneous Rocks, 1914, pp. 454, 455.
[16]*Economic Geology*, Vol. 19, 1924, p. 309.
[17]*Mining Magazine*, Vol. 34, No. 3, 1926, p. 82.
[18]Horace Freeman, *Engineering and Mining Journal-Press*, Vol. 120, 1925, p. 973.

The Differentiation of the Ore Solutions

Under the heading "The differentiation of the ore solutions" Lindgren is vague. It is to be pointed out that magmatic differentiation in the usual sense of the term—meaning the process whereby rocks split up into units of varying composition—must not be confounded with the loss of volatile constituents on sudden cooling. Magmatic differentiation, as Lindgren remarks (in accordance with what I point out in "The Ore Magmas"), does not begin until magmatic equilibrium is distributed by magma surgence, but a long static period of adjustment in a fluid magma is necessary for the development of important rock or ore differentiates. Even pegmatites are characteristic only of rocks which have consolidated under these conditions of very slowly changing equilibrium.

Dikes and Pegmatite Dikes

As to Lindgren's summary of "Dikes" and "Pegmatite dikes," it appears that we are in agreement, except as to his slightly different suggestion that he believes pegmatites normally result from the consolidation of acidic rocks "whether abysmal or intrusive near the surface." To this remark applies my observation on magmatic differentiation above. I do not think, indeed, that Lindgren would maintain this argument, on reflection. Pegmatites are characteristics not only of acidic rocks but of rocks of more femic composition, and they develop only if the time for differentiation is sufficient. Pegmatites, for example, do not develop from the great intrusive masses of quartz porphyries—these porphyries have been fluid after surgence for too brief a period.

Lindgren agrees with me as to magmatic pressure forcing open dike fissures.

Relation of Pegmatite Dikes and Veins

As to the relation of pegmatite dikes and quartz veins, Lindgren is still, as of yore, inclined to be conservative. He has not seen these transitional cases; I have. Yet what he does grant seems to amount to an agreement. "Some of these veins are evidently directly derived from intrusions by differentiation, and so are the corresponding pegmatites." But he is inclined to think the two belong to "two separate successive stages." "It is clear that we have two things: 1, The pegmatite stage; and, 2, the hydrothermal stage, the latter containing much less alumina and more water than the first." To me it is equally clear that there is no such natural classification; certain pegmatitic magmas are assuredly aqueous; and the gradual transition from quartz-feldspar pegmatites to predominatingly or essentially pure quartz pegmatites is one of the commonest field phenomena that I know about. Certainly the

pegmatites and the gold-quartz veins represent, by definition, two stages; but to call one "magmatic" and the other "hydrothermal" is simply to disregard field phenomena, on account of the old assumption that any ore deposit must be deposited by water.

As to the albite in gold-quartz veins, Lindgren says it is "not a magmatic phenomenon at all. It simply forms . . . under certain conditions, the reason for which we do not understand." But where it occurs in pegmatite dikes, as in those described by Schaller and Hess, Lindgren, on an earlier page, believes with me that albite with other minerals is due to "new supplies of magmatic juice of different composition from that of the original dike material," and, like myself, disagrees with Schaller, who thinks they may result from later "hydrothermal solutions." And where albite occurs as practically the only constituent of dikes (albitite) carrying (somewhat later) gold, as described by Turner and by Reid in California,[19] and which I have observed in Cuba,[20] it must be allowed that the albite is a "magmatic phenomenon." The significance of all these occurrences has not been sufficiently emphasized. Also I have pointed out[21] that in the case of the gold-quartz veins of California, as well as those of Ontario and Australia, where the feldspar of the quartz veins is sodic (albite), the alteration of the wall rock in each case has resulted in an increase of potash and a decrease of soda. The vein (veindike) solutions were therefore sodic; but those which altered the wall rock were potassic. "Evidently, therefore, the wall-rock alterations were accomplished, not by the vein-forming magma, but by solutions, gaseous and perhaps liquid, which were excluded from the gold-quartz magma on crystallization."

Neither can Lindgren's disposition of the adularia in Tonopah, for example, as due to country rocks rich in potassium, hold: for I have distinguished six distinct successive vein injections,[22] of which the fourth consisted of mixed quartz and adularia, whereas adularia is rare or lacking in the other stages; but they all lie in the same rocks, or rocks of equal potassic content.

Lindgren writes in the foregoing paper:

'Spurr's conceptions of the California gold-quartz veins are somewhat curious. He says, for instance,[20] that the quartz does not penetrate or silicify the country rock, therefore it must have been deposited by dry ore magmas; in the country rock the alteration is to iron carbonate. I thought everybody knew that the alteration of the country rock is intense and in places, as along the Mother Lode, very extensive. Also that siderite is not one of the alteration products, only mixed ankerite carbonates or calcite with a great deal of sericite, which indicates strong hydration of the country rock from the vein forming solutions."

Concerning this passage, I am forced to say that after much study I have no idea what was in Lindgren's mind when he wrote it. I have noted the alteration of the wall rock of the California gold-quartz veins in various places, emphasizing, as Lindgren has done, that while the veins are siliceous, the alteration of the wall rock has been to carbonates (of lime, magnesia, and iron) with sericite.[24] I am not clear whether some of the iron carbonate occurs as siderite. It does, according to W. H. Emmons,[25] but this point is of no importance whatever. My first thought on reading this passage was that Lindgren meant that the wall rock has been silicified, but on checking up I find that he could not have meant this. In an earlier writing[26] he observed "Replacement by silica is not among the processes here recognized"—and a little later "it seems at first glance strange to see the quartz vein adjoined by a rock traversed in all directions by veinlets of carbonates." Now, we know that rocks of all types are subject to silicification by penetrant solutions. These wall rocks have been penetrated by water proceeding from the fissures, but they did not carry silica. On the other hand, the adjoining veins, which, according to Lindgren as well as myself, filled fissures and are not replacement deposits, are mainly of massive quartz. Surely this demonstrates beyond peradventure that the fluid which filled the veins was not water, but a fluid too dense to penetrate the wall rock—that it was an injected silica magma, from which was given off the water, carbon dioxide, and other materials which penetrated and altered the walls. This, it seems to me, is obvious.

THE FISSURES AND THE FILLING

As to the open fissures, Lindgren agrees with me that they have in many cases been *filled* with vein material. He also agrees that they may have been held open by the pressure of solutions. He disagrees with me as to the manner of filling. He fails to see how an ore magma containing water and other volatiles could fill a fissure solid without constantly ascending supplies of fresh material. The answer to this conundrum is easy and is the same as in the case of a dike, which crystallized from a magma containing a certain percentage of volatiles—a percentage probably considerable in the case of granite and pegmatite dikes. These dikes, it is acknowledged, crystallized from a stagnant solution. The walls, kept open by the magmatic pressure, evidently closed in as the volatiles escaped and the bulk of the rock magma or pegmatite magma shrank. The same explanation applies to ore magmas. Gas-filled small residual spaces—vesicles in certain dikes, druses or vugs in pegmatite and ore veindikes—remain without pressure-closing, because they are isolated and thus strongly supported. In the case of many pegmatite and ore veindikes which are formed at considerable depths and in yielding wall rock, this closing-in pressure has brought the walls together, trapping the crystallizing magma into separate lenses, as I have shown in "The Ore Magmas." I suspect that the application of this principle is broader than I have yet felt free to indicate.

Lindgren cites the Camp Bird vein as a case of deposition from moving waters: "The excellent plates of Ransome so convincingly show the gradual, in part colloidal, deposition from moving solutions that no further argument is necessary." But Ransome, in the same bulletin that Lindgren cites, says:

"In most of the important lodes of the Silverton quadrangle no crustification can be detected. . . . On the contrary, crystallization has proceeded from many points within the solution. . . . It is fair to assume that this structure in veins is the result of the undisturbed crystallization of a nearly motionless saturated solution."

I am in agreement with this.

Similarly, Lindgren cannot accept my belief that

[19]Cited by Lindgren, *Mineral Deposits*, 1919, p. 570.
[20]J. E. Spurr: "The Ore Magmas," Vol. 2, 1923, p. 613.
[21]J. E. Spurr: *Engineering and Mining Journal-Press*, Vol. 119, 1925, p. 890.
[22]J. E. Spurr: *Economic Geology*, Vol. 10, 1915, p. 751.
[23]J. E. Spurr: "The Ore Magmas," 1923, p. 523.
[24]J. E. Spurr: *Engineering and Mining Journal-Press*, Vol. 119, 1925, p. 890.
[25]W. H. Emmons: "Principles of Economic Geology," 1918, p. 237.
[26]Waldemar Lindgren, 17th *Ann. Rep.* U. S. Geol. Surv., Pt. 2 (1895-6), p. 147.

magmatic pyrite-carbonate veins and carbonate veins have been deposited from a saturated solution, which appears at one stage to have been gelatinous. He observes naïvely, "No physical chemist has yet been able to produce a stable carbonate gel." Neither has any physical chemist been able to make a tree; to recall Joyce Kilmer's poem,

> Poems are made by fools like me
> But only God can make a tree.

Nor have the physical chemists made a rock magma nor an orebody—whence one may apply Kilmer's poem to the present instance—

> Geologists may write extravaganzas
> But only God can make bonanzas.

Not that I see any necessity for a *stable* carbonate gel. R. A. Daly, it may be added, has recently described[27] carbonate (mostly calcite) dikes from the diamond mines of Africa, which he regards as essentially intrusive and magmatic.

Ore Magmas and Veindikes

A little later Lindgren again misinterprets my views:

"All ore deposits connected with magmatic emanations (except cinnabar and stibnite deposits) are evidently 'veindikes.' A careful study of Spurr's writings can lead to no other conclusion. The 'ore magma' is differentiated from the parent magma, injected, consolidated. Nothing could be more simple.

"Replacement or metasomatism is an awkward fact to face in this theory, and Spurr touches lightly on it. But this much is clear, that he regards pure replacement deposits like that of the United Verde mine, in Arizona, as 'veindikes.'"

This interpretation finds no foundation in my writings. It is nonsensical to say that I regard replacement deposits as veindikes, or that replacement is an "awkward fact" for my theory.

But Lindgren would not object to calling some veins, veindikes:

"Some magmas or fluids of magmatic origin may fill fissures close to the original source, without appreciable metasomatism. If it is desired to call these deposits veindikes, well and good. . . . . All this will make clear my reasons for rejecting the terms of 'ore magmas' and of 'veindikes' except as they may refer to certain pegmatite dikes and some very closely allied forms of quartz veins."

Here he evidently forgets that on a previous page he decided that a solution which crystallized as quartz alone could not be a magma.

The Inclusions

Under "inclusions," Lindgren describes the inclusion, in veins, of wall rock or earlier-consolidated ore. He touches on the well-known theories, including my own —my own being they are in many cases evidence of a relatively dense ore magma, not "circulating waters"—and thinks all these theories may be applicable. He is not entirely convinced that such fragments have been brought up from great depths by ore magmas. I agree that this rarely occurs, and the same observation holds for foreign rock inclusions in ordinary dikes.

The Ore Zones

Regarding my zonal theory and my interpretation of its various manifestations, in general Lindgren seems to approve. Quite properly, he points out that the problem is a complex one, and that we do not yet know it all. He touches on the succession of crystallization in complex ores, stating that in general zinc blende antedates the copper minerals. He says:

"The succession is in places reversed or changed. Magnetite may follow pyrite and sphalerite may follow galena; sometimes pyrite and marcasite are repeated. Spurr believes this indicates rising temperature; it may be so, but this simple explanation is probably not the only solution of the problem."

I wish to make a correction here. I have advanced the explanation of rising temperature for the reversal of the normal zonal sequence in the case of successive vein injections, but I do not recall that I have done so for the crystallization of complex ores in a "telescoped" ore magma. I would not yet venture to do so. Conditions are different—the laws of eutectics, perhaps mass action, and many other complex physical and chemical laws, including those determined by variability of solvents, enter here. Freeman found that copper sulphide is fused with alkaline sulphides at a lower temperature than is lead or zinc sulphide, the order being the reversal of that indicated in nature by the zonal theory.[28] I could cite many instances of such complex crystallization phenomena, but I believe that where there is a chance of more gradual crystallization and differentiation, even in a complex ore, the normal succession called for by my zonal theory may be most often found—copper minerals preceding those of zinc. Thus in a paper[29] just come to hand, E. S. Moore finds the following succession in a lead-zinc deposit in Canada: pyrite, pyrrhotite, chalcopyrite, and either galena or sphalerite.

Lindgren refers to my observations at Angangueo, in Mexico, where there is a striking succession of great veins, successively injected in successively opened fissures. From a field study of these veins and their relative ages, I determined the general sequence[30] as: 1, pyrite and cupriferous pyrite; 2, blende; 3, galena (argentiferous); 4, silver-bearing quartz; 5, manganese carbonate. Many transitional phases occur. Lindgren proceeds that "the exact succession, as determined by Newhouse," shows galena and sphalerite preceding chalcopyrite. Looking up this reference, I was dumbfounded to find that this evidence, accepted by Lindgren as final, rests not upon any field work but upon the microscopic examination of some specimens sent to the Massachusetts Institute of Technology. Newhouse observes:[31] "No geological description of the deposit from which they were taken is available." Of the different minerals he says, "Little age difference is apparent." Apparently the specimen represented the crystallization of a complex ore. I have no reason to doubt Newhouse's observations, but surely they are only an inconsiderable item in the problem of ore sequence in this district and quite subordinate to the larger relations; and to cite them as conclusive, as Lindgren does, ignoring field relations, is not judicial.

In the next paragraph Lindgren states that I believe that the bonanza ores in general "are deposited under conditions of increasing temperature." I do not believe this. I have never set down such conclusions.

In the next paragraph he cites me as believing (as I do) that cinnabar and stibnite may form from hot-spring waters and implies that I do not believe that gold may be deposited thus. But I have always spe-

[27] R. A. Daly, *Journal of Geology*, Vol. 33, Oct.-Nov., 1925.

[28] J. E. Spurr: *Engineering and Mining Journal-Press*, Vol. 120, Dec. 19, 1925, p. 977.
[29] E. S. Moore: *Bull.* Can. Inst. Min. & Met., 1926, p. 371.
[30] J. E. Spurr: "The Ore Magmas," Vol. 1, 1923, p. 272.
[31] W. H. Newhouse: *Economic Geology*, Vol. 20, 1925, p. 56.

cifically included a certain group of gold ores in this category, and described its association with cinnabar and realgar, from 1895[32] on. In 1925 I wrote:[33]

"In 'The Ore Magmas' I have concluded that a certain group of metals have been dissolved by waters out from the ore magmas proper and thus derived from them. These theoretically water-soluble metal sulphides I reasoned to be arsenic, antimony, mercury, and gold; essentially the group defined chemically as water-soluble by Freeman's experiments."

In the next paragraph Lindgren states that I believe that "all ore deposits of magmatic affiliation have been deposited at minimum temperatures of 365 deg. C., and ordinarily about 400 deg. to 500 deg. C." This statement is quite incorrect. I have assumed the range 575 deg. down to "perhaps 365 deg."[34] for the true ore magmas—not for the group which I have mentioned in my last paragraph above, nor for any minor solution and deposition which hot springs or gases may otherwise have. Lindgren proceeds: "I will simply say that if this were correct, all deposits in limestone would have a gangue of lime-iron silicates." But a little way ahead, under "Contact Metamorphism," he observes contradictorially, even if more intelligibly: "The only condition needed is that the temperature shall have exceeded 500 deg. C., below which limit the lime silicates can no longer form."

Contact Metamorphism

Lindgren here recalls my conclusion that the so-called contact metamorphic deposits are, in all cases which I have seen, simply fissure veins or replacement pipes located somewhere near an igneous contact with limestone, and associated more or less closely with lime silicates, which are mostly older than the ores and mostly have, moreover, no definite space relations with them. In this at last he cites me correctly. In every case of this type which I have seen there is evidence that the sulphide solutions (ore magmas) rose from some considerably greater depth and were not expelled from the adjacent igneous rocks now exposed. The general distribution of these orebodies, indeed, completely negatives any idea that they result from universal magmatic emanations. If they did we should only have to have an igneous contact to have an orebody. But although there are many thousands of miles of igneous contacts, ore deposits are very rare. Moreover, where ore deposits do occur near an igneous contact, long stretches of the same contact are quite barren; and the ore is often notably associated with a small body of igneous rock, while more massive portions near by have no associated ore. In fact, no practical prospecting rules have yet been found that would establish a reliable relation between igneous contacts and ore deposits. Apparently there is no fixed relation, economically, nor, indeed, genetically. I see in these orebodies only a variety of orebodies in general, and visualize their formation from a highly specialized and relatively concentrated type of ore solution (ore magma), which rose from the depth below, from a horizon where not only consolidation but magma differentiation could and did take place. My demonstration of the relations of such orebodies to associated igneous rocks, convincing in their nature, caused Lindgren to admit that this relation is true in some cases; nevertheless, he believes that there are "such a mass of cases where no such deep-seated fissures can be postulated, that it simply seems absurd to me when the actuality of emanations from adjacent intrusions is denied." I do not deny it. I have been looking for such cases and have never found them; and the cases that Lindgren cites in confirmation of his views seem to me to support mine. For example, he cites White Knob, in Idaho, where "the alteration has gone so far that limestone and igneous rock can no longer be sharply differentiated." Certainly in this case he cannot claim that the solutions originated in the igneous rock at or near this horizon and passed out into the limestone: a far deeper source for the solutions which have altered both is demonstrated. Secondly, he cites the map of Copper Mountain by Wright: "I cannot find anywhere a more convincing proof of my views." But Wright[35] reports that "dikes or veins" of the lime-silicate rock "branch out into the limestones and schists and occupy fissures in the granite intrusive."

Are not these fissure veins? Elsewhere the ore, Wright says, "grades into the intrusive mass." This zone of gradual replacement is often many feet wide. There is also a gradual change of the intruded schists, due to replacement. The progress of mineralization is shown by Wright to have been marked by a gradual sequence of events:[36] 1, alteration of limestone and *intrusive diorite* to lime silicates—especially garnet and pyroxene; 2, replacement of calcite by chalcopyrite and pyrrhotite; 3, *filling of fissures* with pyrite, chalcopyrite, magnetite, and other minerals; 4, deposition of zeolite and calcite. There are also associated quartz veins belonging to the later stages of this same sequence.

Altogether the phenomena clearly disprove Lindgren's hypothesis of the derivation of the ores from the igneous rock exposed; these ores must have come from far greater depths, and along fissures (as Wright states[36]) at a period distinctly subsequent to the intrusion of the exposed rock and its cooling.

Conclusion

On examination of this paragraph of Lindgren's paper, as well as his preceding pages, I am impressed with the fact that he has half adopted many of my conclusions. The term "ore magma" is rejected except for "special cases." The term is therefore allowable. Ore solutions may keep fissures open by their own pressure. "The filling was deposited gradually by mobile solutions, not from thick and viscous fluids, though close to the magma the viscosity no doubt was higher than nearer to the surface." He grants, therefore, the occasional viscosity of ore magmas, which is almost as far as I go myself. He makes no mention of "circulating waters," or of "hot-spring waters," according to the pre-ore-magma thought. In a recent paper he even says of a specific case that "there has been an *injection* of highly mobile aqueous solutions."[37] I do not find the time-honored phrase "attenuated solutions" in his paper, a phrase and implication against which I have repeatedly protested; and the banner of the hot-water spring geologists—the word "hydrothermal" (meaning, pertaining to hot water)—is used sparingly. Evidently it also is undergoing obsoles-

[32] J. E. Spurr: *Op. cit.*, Vol. 2, 1923, pp. 699-705 et seq.
[33] J. E. Spurr: *Engineering and Mining Journal-Press*, Vol. 120, 1925, p. 976.
[34] J. E. Spurr: "The Ore Magmas," Vol. 2, 1923, pp. 834, 836.
[35] C. W. Wright: "Geology and Ore Deposits of Copper Mountain and Kasaan Peninsula, Alaska. U. S. Geol. Survey, *Professional Paper* 87, 1915, p. 45.
[36] C. W. Wright: *Op. cit.*, p. 108.
[37] Waldemar Lindgren: *Economic Geology*, Vol. 31, 1926, p. 144.

cence, although it may be applicable to such deposits as those of cinnabar. It is natural that during the three years since "The Ore Magmas" and my supplementary writings began to appear there should have been much assimilation, perhaps partly subconscious, even in the minds of many geologists who have been loath to change their earlier conceptions.

Lindgren emphasizes the great importance of replacement in vein formation. He will find nobody to disagree with him as to this ancient truth. But he does not believe that coarse-grained quartz can be formed by replacement of aluminous rocks. I believe that it may be possible, but that many cases which have been ascribed to replacement are due to fissure filling, as Lindgren does. He rejects the term "veindike," "except for certain pegmatite dikes and other exudation products of purely magmatic origin." That is, he accepts the term as a term. Lindgren grants the existence of unsupported inclusions of country rock in veins, but thinks that in some cases they fell from the walls and were supported by the partly filled vein. As many of these veins show no banding, the partly filled vein must have been a dense fluid, to support them. He decides that he has examined the zonal theory and that in general it is true, but that there are many irregularities—which I have long ago shown. As to the so-called contact metamorphic ore deposits, he does not deny that some may be due to solutions ascending from deep sources.

Altogether, critical analysis would indicate that the effect of this paper is, with reservations, to acknowledge acquiescence to the majority of my revolutionary views, even though his very contentious manner seems to be intended to give the impression that he is protesting; vowing he will ne'er consent, he is consenting.

There remain, however, certain points where a real divergence of views is shown. He does not think there is an unbroken transition from pegmatites to gold-quartz veins. I am sure that there is, and there are many who, having observed this, agree with me. He does not believe that the presence of albite and adularia in veins indicates a relationship to pegmatites. I believe that it often does, especially in the case of albite; in the case of adularia my view is not so well advanced, but it may be so. He does not believe that floating inclusions are "carried up" by vein-forming solutions. I have at different times submitted varied and convincing evidence that these floating inclusions have been transported for varying distances by the ore solutions (ore magmas). He still believes that lime-iron silicates and sulphides may be "a universal phenomenon attending the solidification of magmas." Unfortunately for the prospector and miner they, in point of fact, are not. Emanation of water and other gases from consolidating magmas is a universal phenomenon. But the very fact that orebodies are rare, not universal, constitutes by itself a sufficient proof that these exuded waters and gases are not the ore solutions. By assuming this false identity, marginal ore deposits near igneous intrusives are confused with contact metamorphism caused by these magmatic exhalations. In the study of ore deposits by Lindgren, wall-rock alteration, local or widespread, which is usually due to widespread suffusion by aqueous magmatic exhalations, is confused with ore injection, which in most cases is local and sharply defined (in point of time or place, or both) from such alterations. The two phenomena—one common and widespread and the other rare and highly localized (the first the alteration of rocks, whether or not near igneous contacts, and clearly due to hot magmatic waters or gases; the second, ore injection, which is, wherever it occurs, clearly due to concentrated and highly localized magmatic differentiates—ore magmas) must be recognized as essentially distinct, before we can proceed further with the interpretation of ore deposits. The former (hot water, or gases) are given off from cooling magmas, wherever they occur; but the ore magmas, like other magmatic differentiates, only collect together where conditions are favorable for this and other manifestations of magmatic differentiation, in what I have called the zone of differentiation—a zone whose depth is variable.

Finally, I regret that Lindgren appears to be completely oblivious to what I regard as some of the most important and constructive points which I have brought out in my writings during the last few years; for he does not mention them, either pro or con.

And, as the very last word, I must say that we as yet know nothing as to ore deposits compared with what there is yet to learn. Many clues invite us to further investigation; let us follow them up—that the science may move forward.

Plant of Dolores-Esperanza Corporation, Dolores, Chihuahua, Mexico

Useful Operating Ideas

Dump Doors in Winze Sinking

By C. S. Watt

Assistant Mechanical Engineer, Dome Mines, Ltd., South Porcupine, Ontario

During August, 1925, a winze-sinking record was made at the property of the Dome Mines, Ltd. The winze was sunk from Level 13 at a distance 1,608 ft. east of the main shaft. It was 185 ft. deep on Aug. 1 and was sunk to 466 ft. by the end of the month, an advance of 281 ft. The winze was 7x13 ft. and the total tons of rock handled during the month was 2,150.

As in other shaft-sinking records the saving of time becomes an important factor, and if dumping at the surface is slow, progress in sinking is correspondingly diminished. Part of the usual delays at the dumping point are directly attributable to the design and the mechanical working of the dump doors or aprons which are installed to protect the hoisting compartment when the bucket is dumped. In this particular instance of winze sinking a design was worked out, and dump doors, of a type shown in Fig. 1, were installed in the hoisting compartment of the winze. At *A*, the doors are shown in closed position ready for dumping the bucket and at *B* the doors are shown in the open position when the bucket is being hoisted or lowered. As will be noted the aprons or doors are supported by horizontal bars with trunnion supports at the posts on either side of the compartment. The lower apron is constructed with side plates and angles and plates at the top edge of the sides which, in the closed position, rest on top of wooden pieces, thus affording a complete closure when the door is in use. The bucket is dumped into the lower door, the top door serving as a stop for the lower door and also to prevent the bucket being revolved in the wrong direction. As an additional precaution, the swinging lever at the top automatically drops into a locking position when the doors are closed. A counterbalance weight is arranged to reduce the effort required in opening the doors. This comes into play during part of the travel of the doors, as indicated in Fig. 1. The installation worked satisfactorily and proved to be safe and foolproof. One man is able to close the door, dump the sinking bucket, open and signal to lower in from twenty-five to thirty seconds.

Another design involving a single apron only is shown in Fig. 2. The apron is shown in both the closed position and in the open position. This door was used

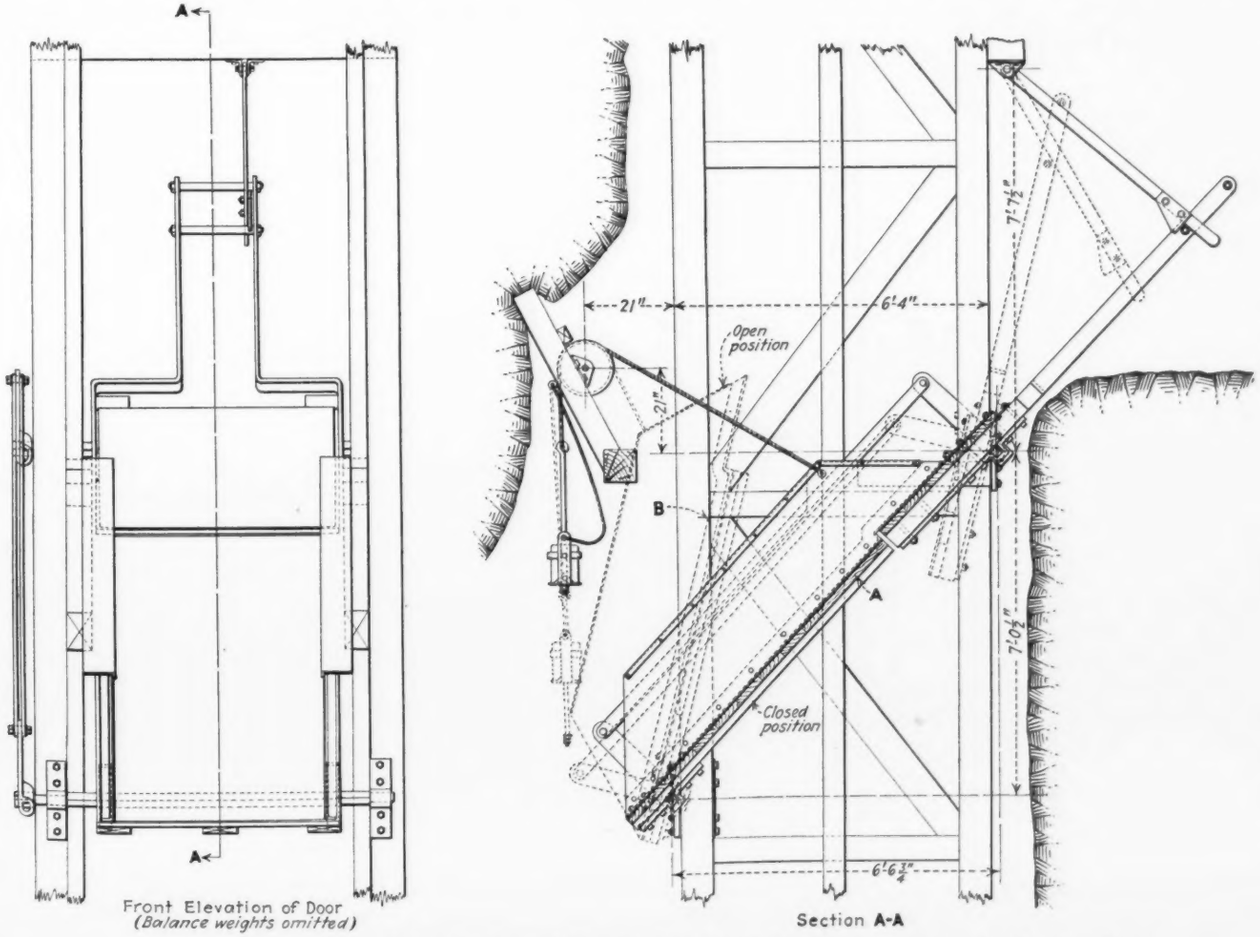


Fig. 1—Double-apron dump door used in winze or shaft sinking. Front and side elevation

for sinking work at the No. 3 main shaft and proved to be a safe, quickly operated door. It is provided with a dump plate extension for dumping a larger-sized bucket. The apron is supported upon hinges bolted to the wall plate. It is provided with side plates and the

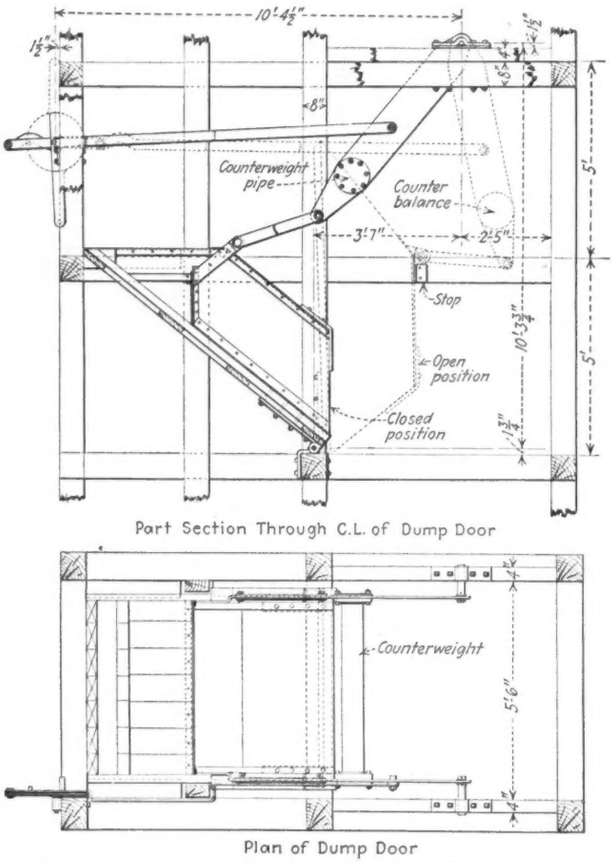


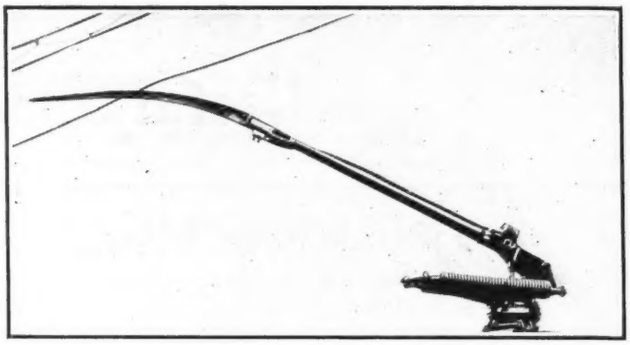
Fig. 2—Single-apron dump door used in winze or shaft sinking

side angles and plates rest upon sealing pieces. In addition it is provided with a removable sole plate. A swinging counterbalance weight is secured inside a steel pipe connected between the two swing arms that support the weight. This form of counterbalance serves the purpose excellently when sufficient clearance for its operation is available, as the effect of the weight decreases and increases in proportion to the weight of the door when opening and closing. Care is necessary, in designing this type, to avoid getting the weight-supporting arms and short connecting links to the door in a straight line, as a strong reverse toggle action takes place and difficulty is experienced in closing the apron. When the apron is closed, it will be noticed that the operating lever arm assumes a dead-center position and remains locked against a stop pin. When the apron is in an open position it rests against two angle stops which also act as buffers.

Side-Arm Collector for Electrified Open-Pit Haulage Locomotive

By Oliver O. Ormond
Superintendent, Wabigon Mine, Buhl, Minn.

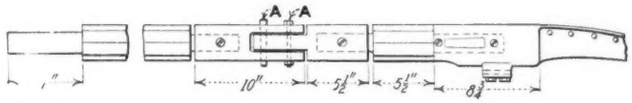
In the electrified open pit and on the dump of the Hanna Ore Mining Co.'s Wabigon mine, on the Mesabi range, the overhead trolley wire is carried on portable poles spaced 40 ft. apart at the side of the track. The



Side-arm collector as mounted on electric locomotive

wire is 15 ft. above the rail and 10 ft. laterally from the center of the track. This position of the wire necessitates the use of side-arm collectors on the electric locomotive in addition to the pantograph collector, which is used when running on the main tracks where the trolley wire runs over the center of the track.

The locomotive carries one of these side-arm collectors on each side. The collectors are air-controlled from the cab. Occasionally they have been broken by poles or other obstructions when they have been left projecting after the locomotive has entered the main line from the dump or loading tracks. To avoid such



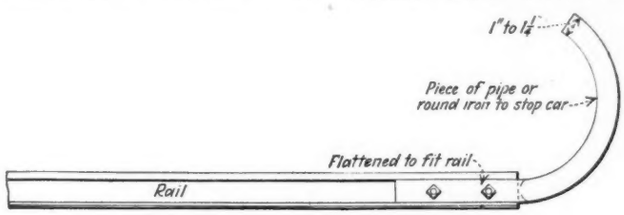
Sketch showing how side arm is cut and how wooden pins are inserted to avoid breaking on striking obstructions

damage the wooden portion of the side arm was cut and jointed in the manner shown in the accompanying drawing. The wooden pins, shown at *A*, shear in case the arm meets an obstruction, and can be easily replaced.

Track End for Dump

By Charles Labbe
Death Valley Junction, Calif.

The most common type of bumper used at the end of a track to stop an ore car is constructed of two pieces of wood held tight on the rails by two bolts. The arrangement is satisfactory as far as dumping is concerned, but where the car dumps into a chute the arrangement shown in the accompanying sketch is



Easily constructed car dump

preferable, as it is quickly made and its use prevents the accumulation of ore or waste at the track end.

The track irons are round iron from 1 in. to 1¼ in. (or pipe) bent over a car wheel, one end being flattened to fit onto the side of the rail and two holes being punched to fit the fishplate bolts.

Discussion

How Impurities Affect Oxygen's Efficiency

THE EDITOR:

Sir—In the *Engineering and Mining Journal-Press* of May 22 I note an interesting article by Messrs. Perrott and Gawthrop, entitled, "How Purity of Oxygen Affects L.O.X." The problem they have so ably worked out might be defined as one of instantaneous combustion and the rapid expansion of the gas products in the union of carbon with oxygen. Quoting the first sentence of the last paragraph in that article, I find this statement: "For maximum strength, liquid oxygen of high purity should be used for liquid-oxygen explosive." This statement coincides with my findings over several years of research work in the combustion of various fuels with oxygen and increased oxygen (by adding oxygen to air feeds).

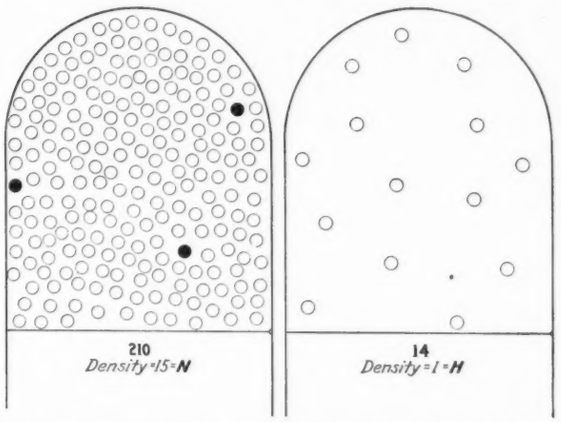


Fig. 1—Diagrammatic representation of the inverted end of two test tubes, the left containing the nitrogen and other inert gases from 1 per cent impurities in commercial oxygen obtained from air, the right containing the hydrogen impurities from commercial oxygen obtained from water by electrolysis

Nitrogen is idealized here as having fifteen times the density and weight of hydrogen in the same volume. Commercial oxygen is always figured on the per cent of purity by volume. By weight, electrolytic oxygen has practically one fifteenth the impurity of air-oxygen.

In my notes of 1918 I find this statement: "The efficiency of commercial oxygen drops rapidly as its impurity increases." Oxygen of 99.8 per cent purity contains only 0.2 per cent of impurity, whereas 0.4 per cent impurity doubles that of the 0.2 per cent. The next step, 0.6 per cent, causes only 50 per cent decrease in efficiencies over the 0.4 per cent. Continuing the line, 0.8 per cent is only 33 per cent of the inefficiencies over 0.6 per cent impurity, and so on. The curve of inefficiency therefore drops rapidly as the impurity increases and gradually flattens out. There is a far greater difference in efficiencies between 99.8 per cent and 99.6 per cent than there is between 85.8 and 85.6 per cent. Reversing the statement, there is more difference between 0.2 per cent impurity and 0.4 per cent impurity than there is between 14.2 per cent and 14.4 per cent impurity. This difference is particularly noticeable when the impurities are inert (as nitrogen in air-oxygen). It is not so noticeable if the impurity be hydrogen that will burn out, giving a heat value.

It seems that the experiments made by Messrs. Perrott and Gawthrop have been made with oxygen obtained from air by the liquid-air process. I note no reference to electrolytic oxygen nor to hydrogen impurities. Admittedly, the electrolytic oxygen, in liquid form, is not so readily obtained, nor are the producers as co-operative in research work as the producers of air-oxygen, but nevertheless there are certain chemical and physical properties that make the experiment interesting and perhaps may have a value if electrolytic production increases in the future.

To the ordinary purchasing agent, oxygen is oxygen, but how about the impurities where percentages of purity are given by volume? Air-oxygen that is 99 per cent pure has 1 per cent of impurities by volume, but it has practically fifteen times the amount of impurities by weight that electrolytic oxygen has of the same volumetric per cent of purity. I will attempt to visualize the condition in Fig. 1, where I have indicated (idealized) 0.1 per cent nitrogen and its accompanying fractional percentages of non-combustible *inert* impurities, collected from 100 volumes of commercial oxygen in the inverted end of a test tube, with 210 molecules indicating its density and weight as compared with the density and weight of fourteen molecules of the lighter and less dense hydrogen.

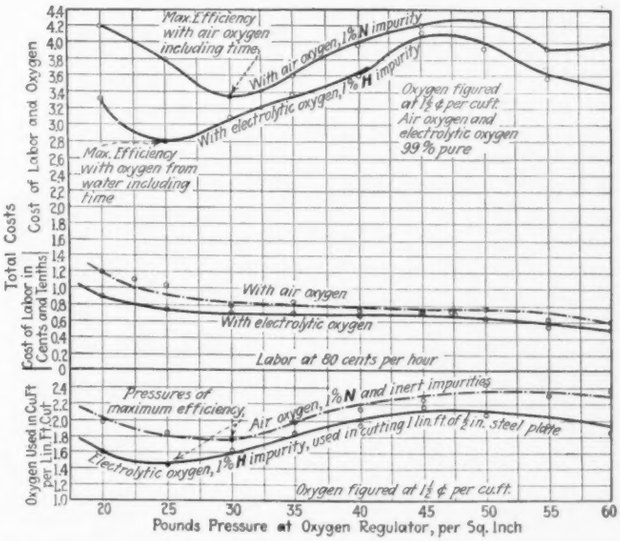

Total Costs
Cost of Labor and Oxygen
Max. Efficiency with air oxygen including time
With air oxygen, 1% N impurity
With electrolytic oxygen, 1% H impurity
Oxygen figured at 1½ ¢ per cu.ft. Air oxygen and electrolytic oxygen 99% pure
Max. Efficiency with oxygen from water including time
Cost of Labor in Cents and Tenths
With air oxygen
With electrolytic oxygen
Labor at 80 cents per hour
Oxygen Used in Cu.Ft per Lin.Ft. Cut
Pressures of maximum efficiency
Air oxygen, 1% N and inert impurities
Electrolytic oxygen, 1% H impurity, used in cutting 1 lin.ft of ½ in. steel plate
Oxygen figured at 1½ ¢ per cu.ft.
Pounds Pressure at Oxygen Regulator, per Sq. Inch

Fig. 2—Oxygen consumption and costs in steel cutting

Analysis was made of both oxygens before and after the test. The iron oxides were gathered, weighed, and analyzed separately. To be alike, both oxygens were obtained at 99 per cent purity. Water-oxygen had 1 per cent H impurity with a bare trace of N from entrapped air in the water decomposed, and a trace of moisture (under four decimal places). Air-oxygen had 1 per cent N impurities, with fractional percentages of other inert gases. All cutting was done in ½-in. steel ship plate, in the same plate with both oxygens.

These fourteen hydrogen molecules, if mixed with seven oxygen molecules, would be an explosive mixture in themselves to add what explosive energy they have to those of carbon and oxygen in the L.O.X. cartridge. Quite certainly it would not make the cartridge any less effective, but how about the 210 molecules of nitrogen? (I am including all other impurities of air oxygen under the one head of nitrogen, for brevity). They do not explode. They are cold; hence they must absorb some of the heat from the explosive action of C and O, reducing the expansive effect of the gases by the amount of head absorbed.

In Fig. 2 I have made a composite charge in which the lower pair of curves show the difference between electrolytic and liquid air-oxygen, each of 99 per cent purity, performing exactly the same work under the same conditions. In this case the oxygen was united with the iron, making iron oxides, in the form of FeO, Fe_2O_3, and Fe_3O_4, and so on. It required more air-oxygen to produce the same number of pounds of oxides than it did electrolytic oxygen. The torch tip and pressure were the same; hence it took a longer time for the same amount of oxygen to come through the same orifice. As length of time increased the volume of oxygen gas, it also increased the fuel-gas and labor cost.

Without going into details of the volumes of research data, those who play billiards will readily understand that it would be more difficult to play the game with 210 inert, useless balls on the table than it would to play the game with fourteen extra balls on the same-sized table that would be bumped off at the first little kiss. The denser nitrogen carries more inert impurities through the kerf to occupy space and absorb heat. The next two curves on the chart in Fig. 2 represent the time or labor increase required with the oxygen-carrying nitrogen impurity over those carrying hydrogen impurity. The lower curves are in cubic feet of oxygen. The two upper pair of curves are figured in cents and fractions, basing the cost of oxygen at 1½c. per cubic foot. The upper pair of curves are erratic after the pressures have passed the point of maximum efficiency. This is due to the wasted oxygen where the speed of the flow caused by excess pressure has permitted more oxygen to pass through the kerf than could unite with the iron to form the iron oxides. The analysis of the iron oxides carefully collected shows that a greater per cent of the oxygen that has passed through the torch is in the iron oxides at the pressure of maximum efficiency and that the pressure of maximum efficiency is lower with electrolytic oxygen than with air-oxygen.

However, we are not discussing steel cutting, but as explosive mixtures are merely problems of instantaneous combustion and rapid expansion of the gases of combustion it seems that the conditions developed in the "oxy-industrial-gas" research might have some point of common bearing.

The electrolytic oxygen can be obtained commercially at purities from 99.5 to 99.8 per cent in all the big cities from daily deliveries in compressed gas cylinders, but it would have to be afterward liquefied, which would in all probability bar it from the field of explosives for the present. Nevertheless, with a view to possible future developments, it does not seem amiss to call attention to the fact that it may be found to have even higher efficiencies than the air-oxygen. I have "exploded" glass tubes with lampblack and oxygen (compressed but not liquefied). I have burned lampblack with oxygen, using both electrolytic and air-oxygen in the experiments. I have burned up (almost exploded) "red-hot iron filings" by suddenly surrounding them with pure oxygen, and from all of my experiments I have drawn the deduction that the efficiency of commercial oxygen is *inversely proportional to its inert impurities;* or it can be worded "directly proportional to its purity," but the latter is not quite correct because there is a difference between oxygens of the same purity when the impurity is inert and when it is combustible.

Tonopah, Nev. LETSON BALLIET.

Grubstakes

THE EDITOR:

Sir—Since the saloon has gone, there is no one to "grubstake" a prospector. I am sixty-three, but am not too old to hunt for a fortune. Several years ago I was on a hay ranch in eastern California near Nevada, and there I saw several pounds of silver ore. I asked where it came from, and they told me that it was found within a hundred miles of there. They gave me the name of the district, and said that there was plenty of the float, but that they could not find the vein. I have prospected a great deal and have always found the lost mines and veins that I went after.

I am sure I can find this silver ore in place. Silver occurs in large bodies and small ones in the vein, and when the ore is exhausted the vein then is composed of what might be called vein matter, sometimes of one character and sometimes of another, carrying a trace of silver. To the ordinary person this vein matter carrying silver looks like country rock. I have prospected enough to know vein matter when I see it. I don't think it has been found, for if it *had* I would surely have heard of it.

I am too poor to advertise, but should like to find some man of means, who is broad-minded and not grasping, to go with me, with first-class equipment, and willing to stay at least three months, for it takes that long, at least, to prospect a district. But many times I have unraveled difficult things in as many hours.

Can you give my name to some one who is willing to take a chance and will not growl if we do not find anything? I am sure I can get samples of the ore at the same place, and if the men are not all dead I can get the exact location of the float. Some of them must be living, as they were twenty- twenty-five, and thirty-five years old at that time. I know within a few miles where the float is.

I should like to go while the weather is warm, as it snows there in winter. I am strictly sober and always was, do not use tobacco, and can take you to men who will give me a gilt-edge recommendation.

Chinese Camp, Calif. C. S. ACKEN.

Tailings at Llallagua

THE EDITOR:

Sir—In these columns in your issue of May 1, 1926, James B. Lewis, of East Malvern, Victoria, Australia, quoted the tailing of the Llallagua (Bolivia) mill as being 1.82 per cent tin. The figure quoted by Mr. Lewis refers to operation of several years ago, and bears no relation to present-day practice. E. H. ROSE,

Llallagua, Bolivia. Superintendent Llallagua mill.

News of the Week

The Mining News given in ENGINEERING AND MINING JOURNAL is obtained exclusively from its own staff and correspondents, both in the United States and in foreign fields. If, under exceptional conditions, material emanating from other sources is published, due acknowledgment and credit will be accorded.

Summary

SENATOR CAMERON fears that the proposed Association of Copper Exporters will develop into a world copper trust dominated by Messrs. Guggenheim and Ryan. He thinks a copper tariff would protect the small domestic producer as well as the consumer.

Developments at the Horne and Amulet properties, in Rouyn, Quebec, continue to add to the ore reserves.

Shipments to the Trail smelter for six months ending June 30 total 274,518 tons against 377,890 tons for the whole of 1925.

Expansion of Katanga copper production hinges in large measure on the ability to obtain common labor.

Utah metal mines paid $8,137,114 dividends in the six months ending with June 30.

Calumet & Hecla Consolidated has increased its mine force by 300 men the last few weeks.

A new high record for gold production (849,214 oz.) was established in the Transvaal gold mines of South Africa in May.

The new flotation of the Tonopah Belmont Development Co., at Hamilton, Nev., will be completed in September.

Large cargo of zinc concentrate and lead bullion leaves Tampico, Mexico, for Europe.

Developments at Rouyn Continue to Reveal Ore

Share Value of Alderson-McKay Soars —Smelter Construction Awaits Completion of Railway

Recent developments at the Horne property of the Noranda Mines, of Rouyn, Quebec, have greatly increased the value of the property. Two months ago a diamond-drill hole intercepted 18 ft. of ore, giving an average assay of $78.20 per ton, taking copper at 13c. a pound. A few days ago this oreshoot was located on the surface. Preliminary assays indicate that it has about the same value.

On the 300 level a drift has been run for 85 ft. and indicates ore from 28 to 32 per cent copper and $8 in gold. The average width has not been determined, but is at least 15 ft. in one place. This body, which has also been found on the 100 level, is the richest yet encountered in the mine. Good progress is being made with the foundation work for the new smelter, but actual construction will have to await the completion of the railway. This has been somewhat delayed on account of the heavy rains and the fact that it is difficult to keep men because the mines are paying much higher wages than the railways.

The stock of the Towagomac Exploration Co., a limited amount of which was recently issued at $1.50 per share, has risen to $3.50 per share. This company owns a 35 per cent interest in the Alderson-McKay properties, and the share price would place a value of approximately $10,000,000 on the Alderson-McKay.

On the Amulet property ore has been encountered in a drift on the 75 level of the No. 4 ore area. Thirty-five feet of this drift shows 7½ per cent copper, 18 per cent zinc, and 3 oz. silver, with practically no gold. Developments on the Amulet have been very promising, and ore reserves have been substantially increased.

Big Export Cargo of Zinc and Lead Leaves Tampico

ONE of the largest cargoes of mine products ever exported through Tampico left that port a few days ago on the steamship Burgendyk, of the Holland-American line, destined for Europe. It consisted of 2,422 tons of zinc concentrates from the Parral mining district, 1,362 tons of raw zinc ore from various points in the interior, 1,469 tons of zinc concentrates from the Zacatecas mining district and 38,909 bars of refined lead from the various smelters in the country. Mining operations in many of the camps and districts of central and southern Mexico have been seriously interfered with during the last few weeks by unprecedented floods. In some communities the homes of many workers were destroyed.

High Grade Reported in Katherine Mine, in Arizona

A strike fault is reported to have been discovered within the big vein at the Katherine gold mine, in northern Arizona, and this has been followed a distance of 80 ft. on the 200 level. It has been encountered also on the 100 and 300 levels. Good assays are reported.

Cinema Experts Visit Michigan Copper Mining District

Bureau of Mines Plans Elaborate "Movie" of Mining and Ore-Dressing Operations

"The Story of Copper," which is being filmed by the U. S. Bureau of Mines at a cost of $25,000, will be one of the most elaborate mining pictures ever attempted by the Bureau. It will include scenes of the copper-mining industry in all parts of the United States and Canada, and will consist of seven reels, 3,000 ft. of which will be devoted to the Michigan district.

M. F. Leopold, safety engineer for the Bureau, has arrived in Houghton to direct the taking of scenes. The picture will include underground work, stamp-mill treatment, smelting, tailings recovery, dredging, plant detail and reclamation. The Michigan district also has been selected for the staging of an early-day prospecting scene.

In addition to the industrial pictures, considerable animated photography will be used to illustrate the complicated processes of the industry which cannot be shown by actual photography.

The Bureau of Mines has made a special study of underground photography and has equipment developed especially for that purpose. The equipment consists of lights aggregating 12,000,000 candle power, generators, and other paraphernalia for producing a light suitable for underground photography. With the lights and methods used, it is possible to bring out every detail in a clear and distinct manner.

"The Story of Copper" will be produced in actual colors, and it is hoped to bring out the various colorings in the rocks and ores in which the copper is found.

Trail Smelter Receives Large Shipments—Rich Orebodies Opened

Heavy shipments of lead and zinc ores and concentrates are being received at the Trail smelter, making it necessary for the Consolidated Mining & Smelting Co. of Canada to start on the erection of a fifty-ton-per-day addition to its lead department, and to ship the excess of zinc concentrates to foreign plants. The first consignment of the latter left the port of New Westminster early in July and other shipments will follow throughout the summer and fall.

It is reported that the Consolidated company has had some trouble with the heating of broken ore in the stopes of its Sullivan mine, necessitating the hasty raising of large quantities of ore to the surface. The new 1,000-ton unit at the Sullivan concentrator is expected to be put in operation soon, and this will relieve the congestion of ore at, and in, the Sullivan mine. The Consolidated company reports that the output of the smelter is well sold.

The Granby Consolidated Mining, Smelting & Power Co. is maintaining copper output at Anyox up to the full capacity of its treatment plants. Its subsidiary, the Allenby Copper Corpoation, is slightly increasing output at Copper Mountain, and now is shipping 1,000 tons of concentrate per week to the Trail smelter. The mill, however, still is being operated well below its rated capacity of 2,000 tons of ore per day. The Britannia Mining & Smelting Co. continues to operate at full capacity.

B. C. Silver Mines, which owns a consolidation of claims to the north and west of the Premier Gold Mining Co.'s holdings, in the Portland Canal division, has run into some lenses and stringers of bonanza ore in a 25-ft. oreshoot, which was recently opened by a crosscut from the bottom of a 50-ft. winze on No. 3 level. Assays have run up to 167 oz. of gold per ton, but the eight to ten tons that is being sacked and shipped daily averages far below that gold content. The full width of the orebody is of milling grade after the selected ore has been taken out.

The Big Missouri Mining Co., which is developing a large consolidation of claims at the head of the Salmon River Valley, has opened by trenches a 4-ft. vein, assaying 12.5 oz. of gold per ton, 80 ft. south of the main orebody, and near to the Unicorn group, which the company recently acquired. The company has developed a large body of $15 ore in the main orebody, but some interesting transportation problems will have to be solved before much commercial shipping can be done.

Abana Mines Installs Equipment

The construction program of the Abana Mines, Ltd., of Dupuy, in the Rouyn gold area of Quebec, is nearly completed. It includes the erection of a power house and the installation of a 100 hp. return tubular boiler, a three-drill compressor, a hoist sufficient to conduct sinking to a depth of 500 ft., and the erection of camp buildings. Mining operations will start in about a week.

Large Increase in Ore Shipments in British Columbia; 377,890 Tons to Trail

THE Consolidated Mining & Smelting Co. of Canada received 274,518 tons of ore and concentrates at the Trail smelter during the half year ended June 30, which compares with the receipt of 377,890 for the whole of 1925. The company's own mines contributed 208,877 tons and seventy-one independent operators provided the remainder. The following independent operators each contributed more than 500 tons: Allenby Copper Corporation, Allenby, 16,404 tons; Bluebell, Riondel, 9,976 tons; Luck Jim, Zincton, 8,977 tons; Yankee Girl, Ymir, 6,040 tons; Stemwinder, Kimberley, 3,638 tons; Quilp, Republic, 3,041 tons; Whitewater, Retallack, 2,061 tons; Silversmith, Sandon, 2,781 tons; McAllister, Three Forks, 1,920 tons; Fork-Province, Zwicky, 1,026 tons; Galena Farm, Silverton, 731 tons; Duthie Mines, Smithers, 649 tons; Paradise, Lake Windermere, 601 tons; Rosebery-Surprise, New Denver, 532 tons; and Ruth-Hope, Sandon, 529 tons.

Geological Map of Southern Yukon Now Ready

A geological map covering a part of southern Yukon on a scale of four miles to one inch has been published. It includes the Whitehorse mining district and covers an area extending from Windy Arm to about 18 miles north of Whitehorse and from 30 to 35 miles east and west of the Whitehorse & Yukon Railway. Copies may be had on application to the Director of the Geological Survey, Ottawa, Canada.

Vipond and Dome Did Better in June

During June the Vipond mine, at Porcupine, Ontario, milled 5,649 tons and recovered $52,400. This is an increase in both tonnage and output over the record for the preceding month. The addition to the mill was practically completed toward the end of the month and enabled a somewhat greater tonnage to be treated. In July the mill should be in a position to treat approximately 300 tons a day.

During the same month Dome Mines, of Porcupine, treated 45,200 tons and recovered $327,644, an average of $7.47 a ton. This is the highest average per ton for some months. The total recovery for the first six months of 1926 amounted to $1,990,189, compared with $2,132,461 in the preceding year.

Conditions at the Dome mines do not appear to be as bad as they are reported to have been, and though the management will make no statement regarding recent diamond-drill results, information confirms the cutting of 30 ft. of ore averaging better than $13 at a point 200 ft. below the lowest level.

Tyee Copper Smelter to Be Converted Into Lead Furnace Plant

Herbert Carmichael has announced that he and his associates, having secured the British Columbia rights of the Gordon process, and options on the old Tyee copper smelter, at Ladysmith, on the east coast of Vancouver Island, and the Tyee and Lenora mines, near by, will proceed at once with the erection of a concentrator and treatment plant at Ladysmith. The arrangement that has been made with Mr. Gordon is that if his commercial plant, which was due to go into operation in July, at Denver, Colo., is successful it will be duplicated at Ladysmith. In the meantime, work on the construction of the other branches of the plant will be put in hand at once.

The old Lenora tunnel is being cleaned out and re-timbered, and both the Lenora and Tyee mines will be operated from it. There is said to be a good body of ore, running around 8 to 10 per cent of zinc and 3 to 4 per cent of copper. This will form the staple supply for the plant, which also will accept custom ores, buying them outright on a unit basis, without treatment charges.

Gordon Process

The Gordon process depends on the solubility of sulphates, basic sulphates, and oxides of copper and zinc in solutions of ammonium carbonate, with which the calcined ore is leached. The copper going into solution is precipitated by metallic zinc, and, after its removal, both the zinc of the calcine and that going into solution to precipitate the copper are precipitated as carbonate by steam, with the evolution of ammonia and carbonic acid, a large proportion of which is recovered as ammonium carbonate for re-use. The residue from the leaching, which is expected to contain the lead and precious metals, will be smelted, and for this purpose the old copper smelter at Ladysmith will be converted into a lead smelter.

Antimony Ore Shipments From Sonora, Mexico

Antimony mines in Northwestern Sonora, Mexico, 110 miles west of Santa Ana, near Magdalena, in the Nogales district, have much ore broken, but hauling has been temporarily suspended, owing to the slump in the market. Most of this ore is of a high grade, largely antimonial oxide. The range of hills containing the antimonial deposits lies northward from Port Libertad and is 30 miles from the coast. Remoteness from transportation facilities prevents its extensive exploitation. The haul by mules requires about ten days for the round trip. About $17, gold, is paid per ton for freight to the railway, and labor at the mine averages about $3 to $3.50 Mexican currency per day.

From Jan. 1 to June 17, 1926, fifteen carloads of antimony ore, weighing 1,424,529 lbs. and valued at $110,270 United States currency, were shipped through Nogales to the United States.

News From Washington

By PAUL WOOTON
Special Correspondent

Labor Retards Katanga Copper Expansion

Belgians Seem Disinclined to Profit by Experience of Others—Agriculture Big Factor—Growing of Adequate Food Supply Must Be Learned

KATANGA competition with American copper will develop much more slowly than is generally supposed, according to reports reaching Washington. The Belgians are comparatively new in the copper business. Their policy of keeping stock ownership in Belgian hands apparently is being extended to the point of excluding foreigners from their operating and technical staffs. This closing of the door in a measure to experience elsewhere is one reason why the opinion is expressed that the African deposits will be developed much more slowly than were those of South America. All of the lessons learned in the development of the American copper-mining industry were available to those who made big producers of the South American properties. Moreover, those mines were near the coast and an abundance of labor was available.

In tropical Africa there has been no security for life or property for centuries. The population is entirely lacking in stability and has no conception of creating permanent individual assets. To plant crops only meant that someone stronger would do the harvesting, so agriculture has not developed. From such a people it is hard to draw sufficient workers who are dependable enough to perform common labor, but it is even harder to find food for the working force needed for the operation of an extensive property.

Before plans for expanding Katanga copper production to its maximum can be carried out, a population must be taught the agricultural arts as well as the tasks which must be performed in and around a mine. In the meantime high operating costs will do much to offset the advantages of exceptionally rich ore, thereby proscribing a distinct limitation around the field in which Katanga can compete.

Editor's Note:

The above Washington letter reflects certain views of official Washington. Due to the fact that policy as a rule prevents government officials from permitting their views being quoted directly, the authority for these reports is necessarily somewhat vaguely referred to. The views reflected from time to time are not those of any one group of officials, but of different men, in the legislative and executive departments. There is no necessary connection between their views and "Engineering and Mining Journal" editorial policy; neither do they necessarily represent Mr. Wooton's personal views. It is felt that the opinions thus faithfully reflected will be of great interest to the industry.

Maganese Production Increased in 1925

THE shipments of high-grade manganese ore, containing 35 per cent or more of manganese, from the mines in the United States in 1925 made a large increase over the shipments in 1924, according to the U. S. Bureau of Mines. Shipments in 1925 by forty-two producers amounted to 98,324 gross tons, compared with 56,515 gross tons by thirty-nine in 1924, showing an increase of 74 per cent. This increase was due to the shipments from Montana. This state produced considerably more high-grade manganese ore than all the other states combined, the Butte district having furnished 47,507 tons of rhodochrosite. Shipments from this district are not regular year by year, and occur only when a considerable tonnage has been developed through the mining of the zinc ore. The second largest individual shipper was the Crescent mine, in the Olympic Mountain region, Clallam County, Wash., from which the shipments for the year were 8,113 tons, averaging 51.64 per cent manganese.

Good Progress on Two Ontario Mill Construction Projects

Good progress is being made with the new 75-ton mill of the Tonopah Canadian Co. which is being erected on their Walsh property in the Gowganda field of northern Ontario. It is expected to be in operation by the end of August. The mill was designed by James Denny, of the McIntyre mines, and is being built under the supervision of Ernest Craig.

At the Canadian Lorrain, in the South Lorrain field of northern Ontario, good progress is being made with mill construction, the foundations now being in place. Part of the equipment has arrived. The program for development includes considerable lateral work on the 420 level, which will be carried on through a winze which is now nearing completion at a depth of 70 ft. below the 350 level.

Plata Mines, Ltd., a subsidiary of the Noranda, Gowganda, Ontario, is installing an electric plant in preparation for an active development campaign. The shaft will be put down from 100 ft. to the 250 level, with the prospect that the rich vein struck on the adjoining Morrison claim of the Tonopah will be picked up.

Apatite Mining in Canada Languishes

"Utilization of Canadian Apatite and Contiguous Resources" is the caption of a report recently issued by the Canadian Department of the Interior. "For the last thirty to thirty-five years," says the report, "apatite mining has at least been stunned, but the progress of science and changes in economic conditions encourage a hope that the industry is but dormant and may again be on the move."

The cost of exploiting deposits of this uncertain nature occurring in a hard crystalline rock is far greater than that of extracting the material of bedded sedimentary deposits, whose thickness is more or less uniform and which lie within a short distance of the surface. This is the main reason why of late years a domestic market which lies within a few miles of the apatite field of Quebec is supplied by phosphate imported from a point 1,500 miles distant and laid down at about $10 a ton, including freight charges of $5 to $6. This is enough to show that the economic possibility of shipping 16 per cent available phosphate rock to any worth-while market in competition with Florida or the more recently discovered deposits in Montana and Wyoming is out of the question.

Timmins and Associates Plan Exploration at Red Lake

Work is to be started immediately on the properties at Woman Lake, in the Red Lake area of northern Ontario, recently taken over under option by Noah A. Timmins, of the Hollinger Consolidated, and associates. The properties, the price to be paid for which is $1,500,000, were staked by W. J. Jackson and M. J. Manion, of Fort William, Ont., and consist of seventeen claims, twelve of which are adjacent to the portage leading from Woman Lake Narrows over to Rowe Lake, aud the other five about three miles south at Medicine Rock, in Lower Woman Lake. A mining engineer and a crew of men have been sent in. Operations will begin without delay at the claims on the Narrows. A large program of stripping and trenching has been laid out, and the group is to be thoroughly proved up by surface prospecting.

Belmont Copper Developing Property at Superior, Ariz.

The Belmont Copper Co., at Superior, Ariz., of which Chester Hoatson is superintendent, is being financed by Michigan interests associated with Scotch capitalists, who are also interested in the Dundee Copper Co. at Jerome, Ariz. This is the third group to undertake the development of this property. The Calumet & Arizona Mining Co. spent approximately $300,000 on it twelve years ago, without finding the orebody. Several years ago the North Butte Mining Co. went in and spent a like sum, also unsuccessfully. The present group later took over the property, and has now succeeded in finding enough ore to justify further exploratory work. There is every promise of opening a new mine.

Fig. 1—Concentrator at Britannia Beach, B. C.

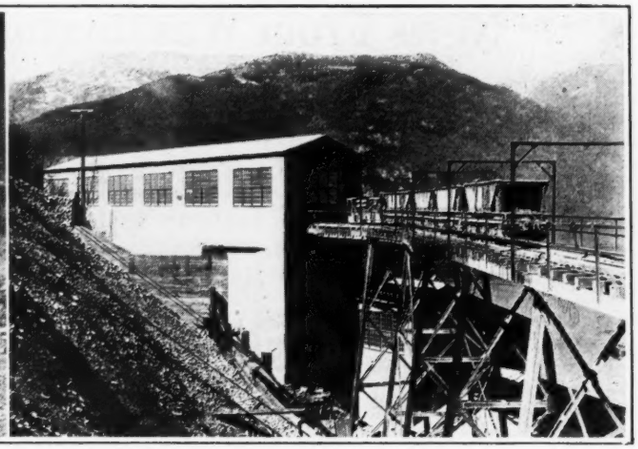


Fig. 2—Ore train delivering ore at crushing plant

Utah Metal Mines Pay $8,137,114 Dividends in Six Months

Utah metal mines paid dividends totaling $8,137,114 during the first six months of 1926. During the first six months of 1925, $6,185,625 was paid.

As result of the discovery of a new mineral channel, production in both the Plutus, owned by the Chief Consolidated Mining Co., and the Mammoth Mining Co., at Eureka, greatly increased. Mammoth shipments increased from 188 carloads to 326 carloads for the period just closed; Plutus, from 62 to 277 carloads. Output of the Bingham Mines Co. declined from 491 to 443 carloads and at Chief Consolidated from 1,485 to 1,210 carloads.

Gross tonnage of ore and concentrates shipped from the Park City district dropped from 209,503 tons to 188,364 tons for the first six months of the current year, by reason of the decrease in Ontario output from 22,284 tons to 10,970 tons, the decrease in Silver King Coalition mine's production from 56,727 tons to 49,230 tons, and the slump in Keystone's shipments from 9,818 tons to 3,742.

Howe Sound Brings Britannia Plant Up to Normal Capacity

Copper Production for Second Quarter 9,016,120 Lb. Against 8,227,371 Lb. in First—Progress of New Haulageway—Recovery by Flotation

OPERATIONS of the Howe Sound Co. at its copper mines near Britannia Beach, in British Columbia, have now reached "normal" capacity. The output for the second quarter of 1926 was 9,016,120 lb. of copper and 3,084 oz. gold, compared with 8,227,371 lb. and 1,844 oz., respectively, in the first quarter. The flotation plant, originally designed to treat 2,500 tons per day, has been so well tuned up that 3,600 tons can be handled, although from 3,000 to 3,200 is normal.

Development in the lower horizons of the mine has been satisfactory, and work now is well in hand for the driving of the new 2,700-level haulageway 500 ft. below the present main adit. Nearly two years will be required to finish and equip the new adit, which will be 6,300 ft. long and will eliminate a long surface haul to the concentrator. The completion of this work will revolutionize mine operations in some respects and is expected to lower costs.

The accompanying pictures show a number of interesting views of the mill. Fig. 1 is a general view of the Beach plant, showing the concentrator in the right center, the incline from Beach to Tunnel railway for passengers and supplies, the hydro-electric power house on the hillside near the center, the general office in the foreground with store building to the left and back of the office and the Beach boarding house to the right of the office. Fig. 2 shows an ore train delivering primary crushed ore to the bins immediately preceding the roll crushing plant. These cars are of 15-ton capacity and drawn by a 15-ton electric locomotive. Fig. 3 shows one row of nine tube mills. A similar row is operating on the next bench above this, both benches being spanned by the electric crane immediately above. The tube mills are in closed circuit with a simplex Dorr classifier. Fig. 4 shows the outer end of conveyor loading concentrate into the hold of a vessel for shipment to smelters. This conveyor is equipped with a steel truss at the outer end, to be raised or lowered to meet the varying conditions of the tide and vessel. Fig. 5 shows a number of the flotation units operating in the central corridor and so placed that one operator may easily watch the work of all the units. Fig. 6 shows a pile of the copper concentrate in a concrete storage bin over which is a 5-ton gantry crane reclaiming the concentrates for shipment by means of a 1½-yd. clamshell bucket which fills the steel hopper on the right, delivering the concentrate to the fast-moving belt which carries the product to the waiting vessel, as shown in Fig. 4.

Some of the ore being treated was broken in 1921, when the present mill was under construction, and owing to oxidation in the stopes the company is not getting as good an extraction from this material by flotation as it does from freshly broken ore.

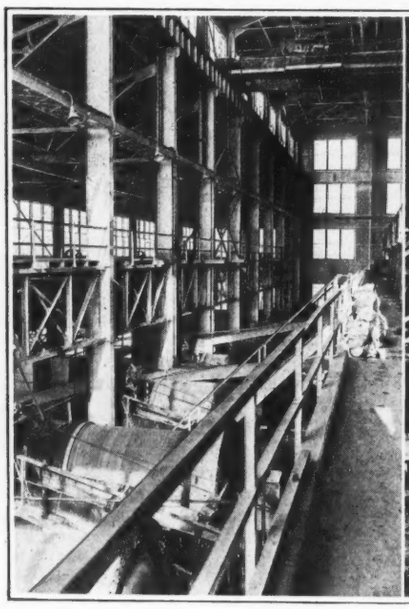


Fig. 3—One row of tube mills grinding in closed circuit with classifiers

Fig. 4—Conveyor loading concentrates into hold of vessel

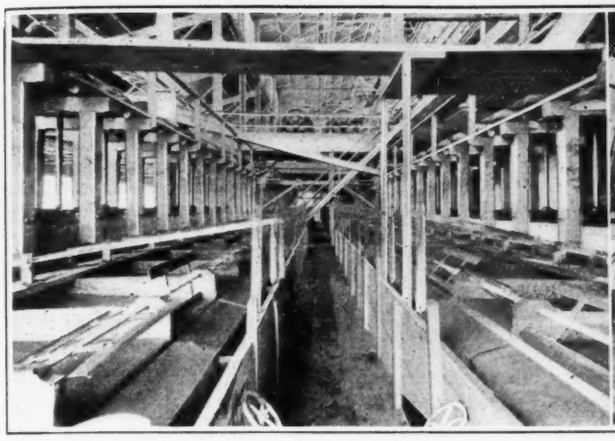


Fig. 5—Flotation units in Britannia concentrator

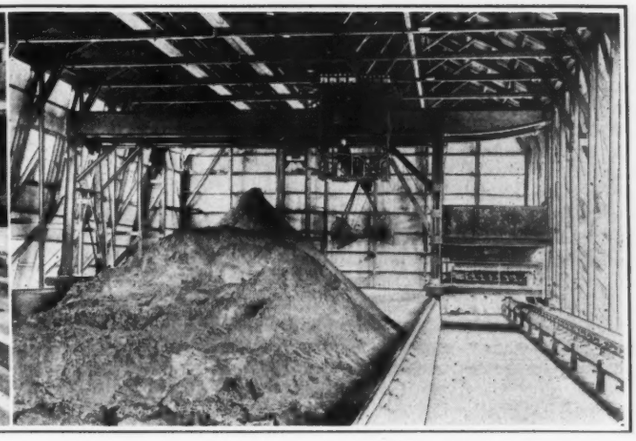


Fig. 6—Copper concentrate in concrete storage bin

Tonopah Belmont Finishes "Float" Plant at Hamilton

Tonopah Belmont Development Co., of Tonopah, expects to have the 50- to 75-ton flotation concentration mill at its Hamilton, Nevada, property, completed and in operation some time during September. Its completion was delayed due to late delivery of pipe and other supplies.

The Belmont company owns what is known as the Nevada and Cornell properties, and commercial ore has been developed on both. Present development is by tunnel and shaft with laterals. The tunnel starts on Cornell ground and extends into the Nevada ground, where it will connect to the No. 5 Level. The tunnel recently cut two new veins, from 18 in. to 36 in. in width, which will average 16 oz. silver and 33 per cent lead across that width.

The topography in this vicinity is very rugged, and the mill is situated at a much lower elevation than the present mine workings, the tunnel being connected to the mill by a 9,000-ft. aërial bucket tramway, with a 200-ton bin at the tunnel and a 100-ton bin at the mill. The tramway is practically completed; and will be ready for operation at approximately the same time as the mill and water line. A considerable tonnage of mined ore is available, in addition to that blocked out in the mine, and company officials expect continuous operation as soon as the preliminary trial run is completed.

Fire Destroys Workers' Homes in Jerome, Ariz.

Two lives lost and seventeen homes burned was the toll exacted by the recent disastrous fire in the mining town of Jerome, Ariz. The fire broke out in the Mexican quarter, on the slope of the hill behind the Hotel Jerome, and in a short time a number of the flimsy buildings were ablaze. Fifteen small houses and two large ones were completely destroyed and several others badly damaged. Few of the buildings were insured.

The fire occurred at 3 o'clock in the morning. Fortunately, some time previous, a stand pipe was installed on the roof of the Jerome Hotel, and from this point streams of water were poured on the burning buildings.

Senator Cameron Sees World Copper Trust in Export Association

Thinks Domestic Industry Would Be Sacrificed—Guggenheims and Anaconda Would Dominate and Would Supply World With Copper From South American and Other Foreign Fields

THE recent conference in Washington between members of the Federal Trade Commission and F. H. Brownell, representing the proposed new organization of American copper exporters, is seen by Senator Cameron, of Arizona, as a step toward the formation of a huge world copper trust. Senator Cameron, according to views expressed in the press, is fearful that the domestic copper industry will be sacrificed and that the smaller producers, in particular, will suffer irreparable injury if the plans as now outlined go through. The dominant figures in the combination are said to be the Guggenheim and Anaconda interests, with J. P. Morgan & Co. in the background of the picture. Mr. Cameron has pointed out that, recently, when New York bankers loaned $50,000,000 to Belgium, they demanded and obtained as collateral liens on various mining concessions in the Belgian Congo.

In a speech on the floor of the Senate on April 9, Senator Cameron declared: "There may exist a possible corporate ambition within these two corporations—those controlled by Guggenheim and Ryan—that after merging their equities, thereby directly controlling 85 per cent of the known copper reserves of the world, they will be able to dictate the price of copper. Their tendency may also be in the direction that monopolies usually traverse: one of temporarily lowering prices to destroy the weak competitors, buy out or reach an understanding with those competitors not easily eliminated, and when this is accomplished they can fix a price for copper products circumscribed only by conscience or economic fear."

Cameron Advocate of Copper Tariff

Senator Cameron's idea seems to be that one effective means of protecting the domestic industry is to establish a tariff wall against the importation of foreign copper He says: "The assumption is tenable that the domestic copper producer can also anticipate within the near future a combined competitive production of at least 500,000,000 lb. of copper a year for years from Peru, Mexico, northern Rhodesia, and French Congo. The copper-mining industry of the United States also is confronted with an output of 1,100,000,000 lb. from Chile, which makes a total competitive production of 2,000,000,000 lb. which can be laid down in New York at 6c. a pound."

Inclusion of Foreign Interests

The inclusion of foreign interests in the operations of an export association under the provisions of the Webb-Pomerene Act probably has never been proposed before. There is nothing in the act forbidding it. The law merely provides that persons or corporations can form partnerships to engage in export trade providing such associations, either in the United States or elsewhere, do not enter into any agreement, understanding or conspiracy, or do any act which artificially or intentionally enhances or depresses prices within the United States of commodities of the class exported by such association or which substantially lessens competition within the United States or otherwise restrains trade therein.

The Webb-Pomerene Act also prohibits unfair methods of competition and provides that every association which engages in export trade must within thirty days after its creation file with the Federal Trade Commission a verified written statement setting forth the location of its offices and the names and addresses of all its stockholders or members, and a copy of its certificate or articles of incorporation and bylaws.

The association is also required to furnish the Federal Trade Commission such information as the commission may require as to its organization, business, conduct, practices, management, and relation to other associations, corporations, partnerships, and individuals.

The meeting at which Mr. Brownell presented the matter was held behind closed doors, and the commissioners

are rather secretive as to what took place. Commissioner Hunt explained that it will be impossible for the corporation to transact any business before fall, since it will be September before the Federal Trade Commission will hold another meeting to act on the proposal.

With the exception of Commissioner Van Fleet and Commissioner Hunt, the other members of the commission have gone home to spend the summer.

Commissioner Houston Thompson and Commissioner John F. Nugent had some intimations of the proposed merger of copper firms for export trade before they left on their vacations, and their friends say they will scrutinize the proposal carefully before giving their consent to the agreement.

Many Have Taken Advantage of Webb-Pomerene Act

More than 500 producers, mills, and factories have taken advantage of the Webb-Pomerene Act to form combinations to export goods from the United States to foreign countries, according to the last annual report made by the Federal Trade Commission. During the last year fifty such associations or combinations filed reports. They are scattered throughout thirty-five states of the Union and export a varied assortment of commodities, including raw materials and manufactured products.

Under the Webb-Pomerene Act such combinations are exempt from the anti-trust laws, but the exemption does not extend to "production, manufacture, or selling for consumption or for resale within the United States or any territory thereof."

The latest figures available show that in 1923 goods to the amount of $153,500,000 were exported by such associations to all parts of the world. Shipments of copper, cement, and phosphate rock totaled 823,000 tons, valued at $68,500,000. Exports of lumber approximated 680,000,000 feet and were valued at $26.000,000.

Canadian Nickel Production Increases

FINALLY revised statistics on nickel production in Canada during 1925, as reported by the mining, metallurgical, and chemical branch of the Dominion Bureau of Statistics, show an output of 73,857,114 lb. of nickel, valued at $15,946,672, compared with 61,356,451 lb., worth $12,126,739, in 1924. These figures for 1925 include nickel in matte exported by the Mond Nickel Co. and the International Nickel Co. of Canada at 18c. a pound; refined and electrolytic nickel produced at Port Colborne, at the value obtained for such products sold during the year; nickel in nickel oxide sold from the South Ontario smelters and from Port Colborne, at its total selling value as oxide; nickel metal sold from South Ontario smelters; and nickel contained in speiss residues exported, valued at 13c. a pound.

London Letter

By W. A. Doman

Special Correspondent

Interest Shown in British Guiana Diamonds—Panama Corporation Has Meeting

London, July 6—Preliminary arrangements are being made for the flotation of the United Diamond Mines of British Guiana, with a capital of £600,000 in £1 shares. From inquiries that I have made it would appear that certain estates in the colony are being acquired for £315,000, though I am told that people with local knowledge would hesitate before paying £10,000 to £15,000 for them. The estates are at present let on tribute, and the diamonds discovered are sold to the owners, who can keep a fairly good eye on the workers. If the estates pass into other hands, it is questionable whether this arrangement can be maintained. As the Diamond Syndicate is mentioned as the buyer of the total production, and as at least one director of the Consolidated African Selection Trust is reported to be on the board of the new concern, there would appear to be something tangible behind the scheme. The prospectus is awaited with interest in diamond circles here, and more should be heard of it in the future.

Having been unsuccessful in 1925 in raising sufficient funds for the erection of a treatment plant, the Indian Copper Corporation, formerly the Cordoba Copper Co., is making another effort. A loan is being applied for under the Trade Facilities Act to provide the plant and machinery, and meanwhile £125,000 is required to carry on during its erection. It is therefore proposed to convert the 2,951,854 unissued 2s. shares into 10 per cent cumulative participating preference shares. As E. T. McCarthy looks for 100,000 tons of 4.12 per cent copper and 81 per cent extraction (the ore is not refractory), the attempt would seem to be worth while making.

So far the public here has not been at all disturbed by the rather gloomy report on the mines of the Rand presented by Sir Robert Kotze, and shares are being bought at advancing prices. I have discussed the position with one or two people who are well informed as to the situation, and they are inclined to shake their heads. It comes to this: As regards good dividend payers the opportunity is being taken to get out, in the belief that the shares can be repurchased cheaper at a later date. The "investment" shares are still in that category, but their potentialities are known, and there is really little movement in prices. On a large block, however, a substantial profit can be made. Some of the smaller shares that are being pushed forward are said to be not for widows and orphans but are the gambling counters of a few financiers. A private cablegram was received from Johannesburg yesterday strongly advising a purchase of Welgedacht Exploration, a company that has lain dormant for years. I cannot find that any work has been done on the property, but the shares are to be taken in hand because Sub-Nigel, some distance to the south, has had the good fortune to strike ore of high gold content.

The statutory meeting of the Panama Corporation was held this morning. Elliott Alves was not present, being confined to his room with, it was said, an attack of influenza. Nothing new was brought forward to show the value of the concessions, but I understand that prospecting is being systematically carried out in areas that are believed to hold promise. This seems to be rather flat after the preliminary fireworks.

Four Companies Develop Manhattan Properties in Nevada

The Manhattan mining district, 48 miles north from Tonopah, Nev., gives promise of considerable activity within the next few months. The White Caps Gold Mining Co. is cutting a station on the 1,310 level, and when this is finished will crosscut to the vein, an estimated distance of 125 ft. Good ore is anticipated, as values have shown a tendency to improve with depth for the last few lifts, and the arsenic and antimony content has decreased.

On the Amalgamated property, a three-compartment shaft has been started and electric equipment is now being installed. This property is controlled by the Thomas F. Cole interests and is well financed for extensive development.

White Caps Extension owns a large area adjoining the White Caps Gold and has recently added several claims to its property.

Manhattan Consolidated owns a large and well-situated piece of ground in the center of the district. Development on this property has been retarded because of uncertainty regarding certain large blocks of stock, which interfered with proper financing, but it is generally believed that at the stockholders' meeting held in Goldfield on July 16 this matter was satisfactorily adjusted.

Calumet & Hecla Increases Mine Force by 300 Men

Calumet & Hecla Consolidated, at Calumet, Mich., is steadily increasing its forces in the Osceola amygdaloid lode shafts, three of which are in commission, Nos. 13, 14 and 15. The company has approximately 4,300 men in its mines, mills and smelter, over 300 of these having been put to work in the last few weeks. Most of the men now being employed are for the Osceola lode shafts. While this vein is not as rich it can be made to yield fair values through close selection. In the conglomerate department, the only electric hoists in the Michigan district are being installed at depth in Nos. 4 and 7 shafts to hoist rock to the 81st level haulage tunnel, through which it will be transported in electric trains to the Red Jacket shaft. They are single drum, 6-ft. diameter hoists, the use of which is one solution of the deep mining problem which confronts the management.

Promising Bentonite Deposit in Black Hills

The Belle Fourche Bentonite Products Co. holds 154 full mining claims of twenty acres each, sixteen of which are located upon an 800-acre tract of deeded land recently purchased by the company, making a total of 3,500 acres, containing deposits of a high grade of bentonite. Much of it is at the grass roots and underlain by a hard and almost perfectly smooth rock floor. The mineral is estimated to average over three and one-half feet in depth on a large part of the tract. It is within one and one-half miles from the terminus of the Black Hills branch of the Chicago & Northwestern Railway and three miles from the city of Belle Fourche, Butte County, S. D. This company was incorporated under the mining laws of the State of South Dakota on March 15, 1923, but production has been slow because of the fact that the many uses of bentonite have not as yet become known.

The company is capitalized for $1,000,000, consisting of one million shares of common stock of $1 each, non-assessable, and mostly held by the original incorporators.

It has been estimated that this tract contains approximately 14,000,000 tons of high-grade bentonite. A large part is of such quality that concentration is unnecessary, it is reported.

Road Under Construction to Spruce Mountain, Nev.

A new road to Spruce Mountain Camp, Elko County, Nev., is being constructed. The highway, which will traverse Spruce Mountain, the uplift on which the mines are situated, will connect the highway from Wells to Ely with Tobar and Jasper, shipping points on the Western Pacific Railway. Construction work is being done by the Russell Freighting Co. and the Black Forest Mining & Smelting Co.

The high price of lead has revived activity in the old camp, first located in 1869. Leasers are shipping silver-lead ore from the Spruce-Monarch mine, the Black Forest, the Bullshead, the Spruce Consolidated, and the O'Neill groups. A two-mile tramway is to be constructed this summer to convey ore from the Black Forest mine to the wagon road.

Work on Sylvanite Mill Begun

The directors of the Sylvanite, of Kirkland Lake, Ontario, have engaged Alfred Byrne, who has recently completed the Anchorite mill, to design and supervise the construction of the mill to be erected on their property. The foundations of the mill are now being made, the location being close to No. 2 vein. Crosscutting is being carried on at the 1,000 level to intersect veins indicated by diamond drilling. A diamond-drill hole on the 700 level has disclosed a new orebody paralleling one of the veins on which considerable work has been done. The drill core indicates good commercial ore across a stoping width.

Johannesburg Letter

By John Watson

Special Correspondent

May Gold Record 849,214 Oz.; Prospective Shrinkage of Rand Output—Diamond Rush to Elandsputte

Johannesburg, June 15—The output of Transvaal gold for the month of May was declared by the Chamber of Mines on June 10 as 849,214 oz., having a value of £3,607,232. These figures show an increase of 45,911 oz., equal in value to £195,018, over the April production, and they establish two new records in the industry—namely, the monthly output and the daily average (32,662 oz.). The native labor returns showed 183,905 "boys" working on the Rand gold mines on May 31, which is a slight increase over the figure at the end of April.

A Blue Book has just been issued in which Sir Robert Kotze, the Government Mining Engineer, sounds a note of warning on the prospective shrinkage of Rand gold production in the next five to fifteen years. He illustrates the meaning of the shrinkage in output by referring to the labor strike in 1922, when the gold output was £11,000,000 short of normal. The excision of that revenue was the chief cause of the severe depression felt in South Africa for at least two years after March, 1922. Nineteen of the gold mines now producing on the Rand, with a crushing capacity of 6,620,000 tons per annum, have a life of less than five years, and eleven more mines, with a crushing capacity of 7,078,000 tons, have an official life of only five to ten years. The fourteen gold-producing companies now working on the Far East Rand have an average life of eleven years. Prudence demands that new mines should be opened up, or present mines extended by the acquisition of more claims. This latter policy has been adopted, to some extent, by the Modder East, Simmer & Jack, Witwatersrand, E. R. P. M., Crown Mines, and Robinson Deep.

On June 10 the greatest diamond rush ever known in South Africa took place at Elandsputte, in the Lichtenburg district, in the western Transvaal. Mining Commissioner Jack was present and read a proclamation, and a flag (a Union Jack) on a bamboo pole was dropped as a signal for the start. Previous to this mounted police had cleared the adjacent country and herded a crowd of 20,000 people (diggers and spectators). About 10,000 runners collected on a line of about 1½ mile. In favorite parts, the runners were fifteen and sixteen deep and in most places seven and eight deep. Ten government officials had been issuing licenses and collected £1,750 for permits during the three and a half days preceding the run. There were claims for all who desired to take them up.

The first post-office service started at Elandsputte on June 10. An authority on alluvial diamonds says there is no other gravel in the Transvaal quite like that at Elandsputte. The smaller diamonds, so far, have averaged £3 per carat. Larger stones, when digging really starts, should bring a better price. There has been a great trek from the Orange River and elsewhere to Elandsputte for the last few weeks.

On the Johannesburg Stock Exchange, during the last week, business has been brisk, owing to London buying orders. Gold shares have shown an easier tendency, but increased attention has been given to diamond shares, Consolidated, Crown, and Tanganyika Diamonds being largely bought. T. C. Lands were quiet until Saturday. Onverwacht platinums have risen during the week from 17s. to 18s. 6d.

Strike of Mexican Miners at Rosario Continues

Martial law has been declared in the town of Rosario, Mexico, where is located the famous El Tajo mine of the Bradbury Estate of California, and federal troops from the garrison at Mazatlan are on duty, following a strike of workmen.

The walkout occurred when the mine management refused to concede to demands of union leaders, who represent 200 workmen. Families of workmen are reported to be suffering from want of food.

Following disorders several months ago, the government unsuccessfully attempted to bring about an adjustment of differences. Governor Vega again is attempting to bring about mediation, having sent his personal representative to Rosario with heads of the state labor union.

Tough-Oakes Burnside Operating at Increased Capacity

The enlarged mill of the Tough-Oakes Burnside, operating in the Kirkland Lake area, Ontario, went into operation July 10. Increased capacity now gives a tonnage of at least 160 tons as compared with 110 tons a day. New rolls were installed in the mill, and these will permit of a finer and greater crushing capacity. Considerable ore is in sight ahead of the mill, and it is anticipated that a better grade will be found in the veins now being opened up. A new orebody has been picked up to the west of the diabase dike on the 1,225 ft. level of the Tough-Oakes.

Gold Circle Claims to Be Developed

The Gold Circle Consolidated Mines Co., organized by State Senator Noble Getchell, of Nevada, and financed by Boston capital, has acquired title to a number of Gold Circle (Nevada) properties, including the Elko Prince, Missing Link, General Grant, and other claims. Operations have been started from the Missing Link and the General Grant groups.

The new 75-ton mill being constructed will be ready for operation by Christmas. Mr. Getchell, who is manager of the Betty O'Neal Mining Co., Battle Mountain, Nev., will be in charge of operations.

Societies, Addresses, and Reports

Australian Gold Producers Contend for Bonus

Government Allotment of 20s. per Ounce Would Cover Increased Costs and Solve Unemployment

At the recent annual meeting of the Chamber of Mines of Western Australia, held at Kalgoorlie, the president of the Chamber, Rd. Hamilton, in the course of his annual address, made a report on the joint efforts of the Chamber and of the Gold Producers' Committee of Melbourne, representing all of the gold miners of the commonwealth, to obtain government aid for the gold-mining industry of Australia. Mr. Hamilton said, in part:

"It is regrettable that there is no improvement shown in the state of our industry during the year. The gradual reduction in the amount of gold produced still continues. The general cost of production cannot but remain at a high level while the tariff is highly protective, while many of Australia's primary products command high prices in the markets of the world, and while the state governments continue their present policy of lavish borrowing. The states cannot go on borrowing indefinitely, and, as world affairs return to the pre-war normal standard, the world prices for such staple commodities as wheat and wool must come down. Meantime, it is inevitable that an industry like ours, which cannot meet the increased cost of production by putting up the price of its product, should suffer, and suffer severely, unless some compensatory means can be devised for obtaining an increased price for its product.

Would Equalize Pre-war Cost

"For this reason the Chamber, in cooperation with the Gold Producers' Committee in Melbourne, which represents the gold-mining industry of the whole of Australia, has been strenuous in its efforts to obtain from the Federal Government a bonus of 20s. per ounce on all gold produced in the commonwealth. That sum is considered to be about equivalent to the increase in the cost of production, as compared with the cost before the war. So far, the efforts put forward have not been successful, but the council is not without hope that it will succeed in convincing the general community and the Federal Government that the gold-mining industry has an equal right to government assistance with any other primary or secondary industry in Australia. A country with plenty of active mines makes rapid progress, and Australia with its vast empty spaces should do its best to encourage all kinds of mining. Australia is in great need of immigrants, and is spending much money in settling them on the land. If the bonus on gold were considered as part of the immigration policy, it would be an effective way of drawing a very desirable class of people from the homeland. A large percentage of the present unemployment in Great Britain is due to the depression in the coal-mining industry. If gold mining were resuscitated throughout the commonwealth by payment of the suggested bonus, it would probably attract numbers of miners from the Old Country, strong and capable men, who would want little or no training, and who might eventually, like so many of our own miners, turn their attention to farming. Thus the gold bonus, while helping Australia, would also act to the relief of the motherland.

Benefits to Public

The proposed bonus, if granted, would benefit the commonwealth by increasing employment, promoting general prosperity and attracting population and capital.

"The tonnage of ore treated last year amounted to 800,297 tons (2,240 lb.), in the previous year 783,760 tons, which shows an increase of 16,537. The yield of gold for 1925 was valued at £1,845,780; for 1924, £1,946,343, a decrease of £100,563. Dividends paid in 1925, which were paid by two or three mines only, amounted to £54,109; in 1924, £124,771, a decrease of £70,662. The average grade of the total ore treated in 1925 was 10.85 dwt., in 1924 the grade averaged 11.69 dwt., a decrease of 0.84 dwt. It is safe to say that any new discoveries will not raise the general average above that grade when a similar tonnage is treated per annum, but the grade is not high enough to pay present costs and leave a margin of profit sufficient to induce investors to buy and equip mining properties. The only possible way to revive the gold mining industry of Australia is to increase the value of the product to the gold producer. Gold mining in Australia has ceased to be a high-grade proposition. A bonus of 20s. per oz. would make payable a tremendous quantity of low-grade ore in this state alone, and would make that wealth available for the use of the commonwealth. Such a bonus would send prospectors out all over the country, reopen deserted mines, and open up new ones in many parts of our vast auriferous area.

Gold Mining Promotes Prosperity

"Nothing produces and distributes wealth more quickly than gold mining, and, therefore, there is no better incentive to immigration. No industry more readily attracts capital, and the cost of the bonus would soon come back in the shape of foreign capital for investment. As a means of opening up and developing the country gold mining is unrivaled; it establishes prosperous centers everywhere, and so acts as a strong decentralizing influence. No industry employs so large a number of men in proportion to the value of the product. Gold mining pays in wages to the actual mining employees at least half the cost of production —a far higher proportion than any other industry, to say nothing of the many ancillary industries it supports. The gold it produces is distributed wholly in the commonwealth; all but a percentage on foreign investments. It creates markets within the commonwealth for the products of secondary industries. It requires and maintains all kinds of public services. It gives permanent work at good wages to a large number of men who will contribute to commonwealth and state taxation.

"Also, the proposed bonus, even if in two or three years it were doubled or trebled, would be an excellent investment for the government, as most of it would come back indirectly in the shape of the benefits mentioned. The gold-mining industry is a truly national one for every state in the commonwealth is more or less a gold producer.

"With the object of making the occupation of mining more healthy the government of this state is now enforcing the withdrawal from the mines of all men who are suffering from tuberculosis, who will be supported by the state, but the government intends to throw all the cost of compensation for industrial disease, apart from tuberculosis, on the mining companies, and there is grave fear that the insurance premium may be so heavy as to compel some of the country's mines to cease operations."

Nine Years Minimum for Degree of "Engineer"

Nine years will henceforth be the minimum time in which the degree of "engineer" may be won from Lehigh University, says an official statement by Charles R. Richards, president of that institution, issued on July 11. Beginning with the entering class next fall, the usual four-year course will lead to the degree of bachelor of science in the various branches of engineering. Five years of acceptable practical experience in responsible charge of work after graduation and the submission of a suitable thesis will be required before the university will stamp a candidate as a full-fledged civil, mechanical, electrical, or chemical engineer.

Coincident with this change will come a revision of the courses of study by which greater emphasis will be placed on the fundamentals of engineering, mathematics, physics, and chemistry, and less emphasis on the specialized details of engineering practice. In addition, these revisions include an increase in non-technical subjects, such as social sciences, fine arts, and business administration.

Lake Superior Institute at Ironwood

The Lake Superior Mining Institute will convene at Ironwood, Mich., late in August or early in September, definite dates remaining to be set. The members probably will spend only one day at Ironwood, holding the remaining sessions at Minneapolis, Milwaukee, or Chicago.

The Mining Institute includes mining men from Michigan, Wisconsin, and Minnesota in its membership. E. W. Hopkins, of Ironwood, is president.

People You Should Know About

H. C. Boydell is doing examination work at Tyrone, N. M.

Donald M. Liddell will return from Europe early in August.

M. E. Pratt is now field engineer for the California McVan Co., of Sacramenta, Calif.

Newton Dunyon, Salt Lake consulting engineer, is in Nevada making a mine examination.

C. M. Weld, consulting engineer, has returned to New York from a brief professional visit in Louisiana.

L. O. Howard, dean of the School of Mines and Geology, State College of Washington, was in New York last week.

P. Bouery, hydraulic mining engineer, recently left San Francisco to make examinations of hydraulic mining property in Southwest Alaska.

Charles Rhodes, of Auckland, New Zealand, managing director of the Waihi Mining Co., is visiting the mining regions of northern Ontario.

R. S. G. Stokes, superintendent of the De Beers Consolidated Mines, Ltd., recently left Capetown, with his family, for England, on six months' leave.

John G. Kirchen, general manager of the Tonopah Extension Mining Co., at Tonopah, Nev., has returned to Tonopah from a trip to Eastern cities.

E. J. Raddatz, president and general manager of the Tintic Standard Mining Co., has returned to Salt Lake after a six months' trip around the world.

W. C. Ringsleben, geologist, of Hollinger Consolidated, of Porcupine, has gone to Red Lake to make an examination of the holdings of that company.

Djevad Eyoub, geologist with Henry L. Doherty & Co., is in New York for a visit after two years' field work along the border in Mexico. He expects to return to Laredo, Texas, soon.

Bernard Price, chief South African engineer to the Victoria Falls & Transvaal Power Co., Ltd., accompanied by Mrs. Price and their son, recently left Johannesburg on a visit to England.

A. J. Dunn, editor of the *Wallace Miner*, and correspondent for the *Engineering and Mining Journal* at Wallace, Idaho, made a vacation auto trip with his family through southern Idaho in July.

R. H. Sargent, of the Alaskan Branch of the U. S. Geological Survey, accompanied the expedition from the Navy Department which is to make aërial photographs in southeastern Alaska.

Carl Davis, consulting engineer to the Anglo-American Corporation of South Africa, Ltd., left Johannesburg on June 9 for South West Africa, on a visit to the Consolidated Diamond Mines. He was accompanied by Mrs. Davis.

F. W. Bradley, president of the Yukon-Treadwell company, which is developing the old Tybo mine, 60 miles east from Tonopah, Nev., was in Reno recently to confer with **W. H. Blackburn**, who is in charge of this work.

Leland Russell van Wert, for the last six years a member of the faculty of the Harvard Engineering School, has been named assistant professor in metallurgy at the Carnegie Institute of Technology for next year, according to an announcement from President Thomas S. Baker. The appointment is announced as a further step in the reorganization of the Department of Mining and Metallurgical Engineering, Professor James Aston, former metallurgical engineer with the A. M. Byers Company, having been placed in charge of the department several months ago subsequent to the death of Professor Fred Crabtree and the recent resignation of Professor F. F. McIntosh.

Leland Russell van Wert

Russell van Wert was graduated from Union College in Schenectady, N. Y., with a B.S. degree in 1916, and later studied as a graduate student in metallurgy and metallography at Yale, Massachusetts Institute of Technology, and the School of Mines and Engineering at the University of Arizona. At the latter institution he was Arizona State Bureau of Mines Fellow, and served also as assistant in the U. S. Bureau of Mines at Tucson, Ariz. His experience has included positions as metallurgical engineer with the Ordnance Department of the U. S. Army, research engineer with the Dorr Company in New York City, metallographist with the Remington-Arms Union Metallic Cartridge Company in Bridgeport, Conn., and since 1920 he has been instructor in metallurgy at Harvard University. He will join the staff at Carnegie in September.

Obituary

E. C. Lemieux, prospector of the Yukon and Alaska, died at Cobalt, Ont., on July 10, at the age of fifty-eight years. He was a native of Ottawa, Ont., and was a noted musician and composer. He is survived by two daughters.

William Andrew McDowall, foreman in the assay department at the Rand Gold Refinery, Germiston, in the Transvaal, where he had been since March, 1922, died there recently. Previously, for twenty-two years, Mr. McDowall had been engaged in the Royal Mint, Perth, Western Australia. He leaves a widow and two children.

Philip Lyttleton Gell died recently in England. He succeeded the late Dr. Jameson as chairman of the directors of the Chartered British South Africa Company. He was the author of an admirable biography of the late John Richard Green, the historian, and was a grandson of Sir John Franklin, the Arctic explorer. He was seventy-four years old.

Captain W. Timmins, mining engineer, of Mine Centre, Ont., was drowned on July 11 by the overturning of a boat, in which he was taking an excursion with his wife and four children. He succeeded in saving the lives of his wife and family, but was overcome by exhaustion and perished. Captain Timmins was an Englishman, and was mining captain for the Foley mines, at Mine Centre. He was formerly in Porcupine.

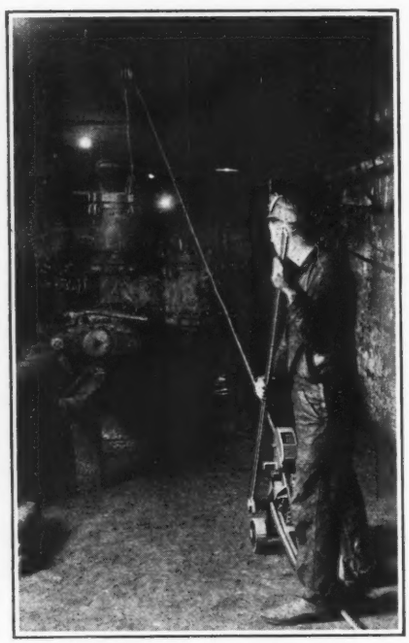
Hugh Robert Trenholm, manager of the Knight mines at Eureka, Utah, a veteran of Silver Reef, Klondike, Goldfield, and Tintic, died at Provo, Utah recently. Mr. Trenholm was born at Grandpre, Nova Scotia, Canada, in 1873. At the age of nineteen he came to Salt Lake City and then drifted to Mercur, where he did his first mining. After experience in Alaska, Mr. Knight went to Pioche and other Nevada camps, finally settling down as superintendent of the Swansea mine, at Silver City, Utah. Here he met and married Mary E. Osborn on Jan. 1, 1901. After trying farming in Idaho, he went to Goldfield, where he became superintendent of the Goldfield Consolidated. This position he held until the time of the strike, when on disagreeing as to questions of policy regarding the settlement of the strike, he returned to Utah. In the fall of 1911, he went to Rico Colorado to take charge of the Rico Wellington mining company's property, of which Jesse Knight, of Povo, owned control. Ever since 1911 until his death Mr. Trenholm was associated with the Knight investment company mining ventures in Colorado, Missouri, Nevada, and Utah. Following the death of Jesse Knight in 1921, Mr. Trenholm became manager of the Knight properties. At the time of his death he was greatly encouraged by the fact that developments in the Iron Blossom, the Empire Mines, and other properties were vindicating his conclusions concerning the mineralogy of the district. Mr. Trenholm was superintending operations at the Empire mine when he was stricking with acute tonsillitis, which developed into the sleeping sickness. He was widely known and highly respected among Western and Utah mining men. His democracy, optimism, great physical strength, unimpeachable integrity, and his remarkable ability as an operator will make him long and pleasantly remembered by all who came into contact with him.

New Machinery and Inventions

A Powerful Little Puller

Occasions frequently arise in and about the mine when something heavy must be pulled, transported or lifted. The little lifting jack shown in the accompanying illustration, known as the Handy-Andy puller, and manufactured by the John Waldron Corporation, of New Brunswick, N. J., has been designed to fill exactly such needs. It is a compact unit, simple in construction, rapid in operation, and easy to handle. It is practically a pulling-jack.

This machine is constructed of steel throughout, no cast iron being employed. It is fitted with two small truck wheels to facilitate its transportation from place to place. It is built for operation by one man, and two speeds of cable pull may be obtained.



Ready to lift a pump chamber

This shows the pulling device described in the text in the pump room of a mine. The simplicity of the hook-up will be readily perceived. In this case a tail cable or anchor is attached to the rear end of the machine, and the lifting cable led over a snatchblock and then down to its fastening on the valve chamber.

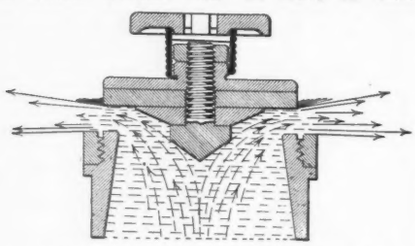
Without the aid of tackle and in a straight line this machine is said to exert a pull of 10 tons. With one block, therefore, it naturally will pull 20 tons and with two blocks, 40 tons. The drum holds 60 ft. of §-in. cable. It is designed so compactly that it can be used in close quarters, and it will work in any position on the ground, or in the air, when an extra heavy pull is put upon it. It is fitted with an automatic reverse which enables a man to lift a load, and then lower it again. The operating bar or lever is 5 ft. long, making the operation of the machine as easy as rowing a boat. It will be readily perceived by mining men, especially those in the construction and operating departments, in how many places this machine can be used to advantage.

A Stream-Line Pump Valve

One of the latest refinements in pump valves is seen in the Williams-Bullen pump valve shown in the illustration. Its designers and makers have endeavored to combine in it all of the features that are essential to maximum efficiency. The valve is strong and sturdy, and simple as well, having but four parts. To assure sensitivity it is made as light as possible, so that its action is practically instantaneous; slippage is cut almost to zero. Leakage troubles are eliminated.

One of the radical departures from orthodox design is the elimination of web pieces from the inside of the valve. Inside webs and obstructions are poor design, because at that point the fluid velocity is necessarily highest. By removing the webs the velocity is reduced and efficiency is therefore bettered considerably.

Broken studs are common in old-style valves. To eliminate that trouble a Tobin bronze stud is used in this valve. Upkeep costs are thereby greatly reduced.



Sectional view of new pump valve

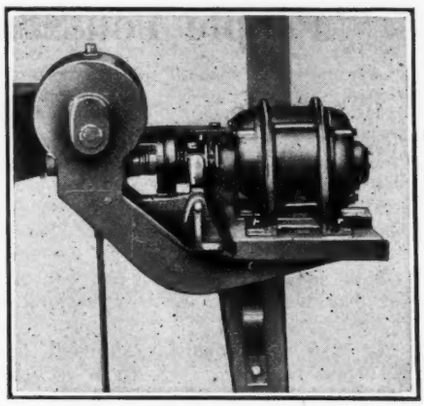
Then, as a finishing touch, the designers have built this valve along "stream-line principles," as shown in the illustration. By making the interior as smooth as practicable, by eliminating abrupt turns, by observing the laws of hydraulics, fluid friction is reduced to the minimum, all of which should add to the over-all efficiency of the entire pump.

The valve body is made of government bronze. The disk, usually made of "Wigaco," will be made of any other material suitable for whatever the special pumping problem may be. The Williams Gauge Co., Pittsburgh, Pa., is the manufacturer and distributor.

Speed Reducer Unit Introduced for Small Machines

The "Motor-It" speed reducer unit is being marketed by the Utility Manufacturing Co., Cudahy, Wis., for use with any type of small machine. The unit pictured has a disk clutch operated by means of a foot lever and is intended for short intermittent operation. For longer intermittent operation an expanding-type clutch is furnished, and for an electrically controlled machine a flexible coupling is used.

The motor runs at 1,800 r.p.m., and any desired speed reduction can be specified. Reduction is made by means of a worm and wheel or spiral gears. Roller or ball thrust bearings are used.



This speed reducer has a disk clutch which is operated by a foot lever

These units can be applied to any type of machine now driven by means of a belt or gear. The new unit can be put on the shaft in place of the tight-and-loose pulley or clutch, since the unit is bored to fit the customer's shaft. The gear set is completely inclosed.

The unit is furnished with motor, clutch, and reduction gear. The motor is supplied in ¼-, ½-, ¾-, 1-, 1½-, and 2-hp. sizes.

Portable Adder Lightens Office Work

A low-cost, portable adding machine for retail stores, offices, weigh houses and the like has been developed by the Burroughs Adding Machine Co., of Detroit, Mich. This new machine is notable both for its compactness and its light weight. On a desk or counter it takes up little space, slightly more than the average letterhead. It can be carried easily from place to place for use wherever needed.

In many ways this machine can be compared with the larger machines of this builder. It is equipped with a standard keyboard containing eight rows of keys, and it has a total adding capacity of $999,999.99. Its work is "visible," always in full view of the operator. It is also equipped with the regular keyboard features of the larger machines, such as total and sub-total keys, error key, repeat key and non-add key.

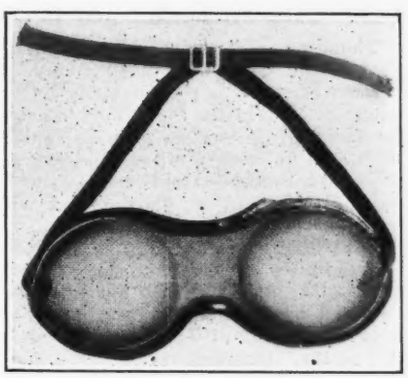
A portable adding machine that may be used to advantage in office or weigh house

Speedy operation of the machine is assured by the one-hand control design. Only one hand is needed for operating the entire keyboard as well as the adding and printing mechanism. The left hand is always free to follow or turn the items that are being added. It uses standard-width roll paper, but the carriage is wide enough so that the machine can be used for making out bank-deposit slips, customers' statements, and various business reports. This machine is not limited to any particular kind of work. In fact, it was designed to handle practically all kinds of adding encountered in the small business office where the volume of work requires a machine that is simple and inexpensive.

An Unbreakable Eye Protector

In order to meet the demand for a device that will effectively protect the eye from injury by flying particles of coal or other material underground the Mine Safety Appliance Co., of Pittsburgh, Pa., has developed a wire-screen goggle.

This is made of strong steel wire of a color and mesh such as to avoid optical distortion. Inasmuch as the wire is close to the eye it has no other effect upon the sight than to merely darken the field of vision to an extent that is negligible.

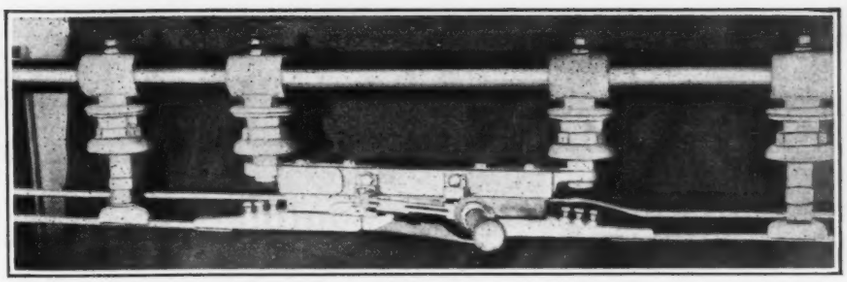


These goggles cannot be broken by flying particles

These goggles are said to be not uncomfortable to wear. The rim is leather-bound, and no metal parts come in contact with the skin. Because of its flexibility and the ready adjustment of the head band this goggle can be easily formed to fit the nose and face of the wearer. If deformed by a blow from flying coal it may be readily bent back into shape.

Another Use for a Ford Truck

A Ford truck has been placed in commission at the El Palmer mines, at Santa Barbara, Chihuahua, Mexico, for the operation of a jig and a small Gates crusher. The small concentrating plant will handle about eight tons per shift of eight hours. Three men in the mine produce the ore and two men operate the mill. At the end of the shaft the rear wheel is put back on the truck, and concentrate loaded and taken to the town of Santa Barbara and stored until sufficient tonnage is accumulated for a carload shipment to the smelter. The ore occurs in small stringers, and would not pay to freight such a long distance to the railroad station. By the use of this small crusher and jig the ore can be reduced in sizes and concentrated, with the result that a reasonably good product can be sent to market.



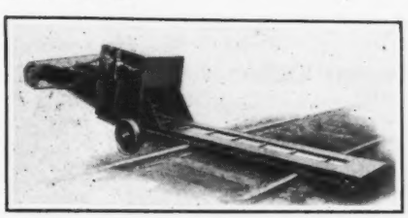
Section switch well anchored at both ends

Unloads Hopper-Bottom Cars; Feeds Elevating Conveyor

The accompanying illustration shows the new car unloading machine recently developed and placed on the market by the Chicago Automatic Conveyor Co., Old Colony Bldg., Chicago, Ill. This machine is intended for the unloading of sand, gravel, crushed rock, coal or other granular materials from hopper-bottom cars and in such work does away with practically all shoveling. In use it is pushed under the car and across both rails and, with the aid of a second conveyor, if necessary, delivers the material from the opened gates to trucks, bins or to open storage.

Tests of this machine made under exacting conditions show that it will handle the contents of a 50-ton car in less than an hour and there is no reason why it could not be speeded up to handle twice this amount. The receiving end is only 3 in. high above the rails and consequently does not interfere in any way with the drop bottoms. Its sturdy construction will permit it to receive without injury any outrush of material even though the doors are opened wide.

No pits and no spotting of cars are necessary. The discharge end is elevated to a height that will allow delivery to a second conveyor without any big lumps rolling backward. The machine is mounted on wheels and may thus be readily transported. The makers assert that it is both economical and flexible in operation and that it will do much to ease the labor and lessen the expense of unloading hopper-bottom railroad cars.



No pit necessary

This machine, or rather the receiving end of it, is so low that it can be pushed across the track under a car without in any way interfering with the action of the hopper doors. It delivers to a second conveyor, which can discharge either to a truck or to storage.

Section Switch That Abuse Will Not Displace

In most mines it is highly advantageous to install section insulators so that the portions of the workings that are supplied with current through them may be completely isolated so far as the power is concerned. The accompanying illustration shows the new section insulator recently placed on the market by the Electric Railway Improvement Co., of Cleveland, Ohio. This switch has a double blade and as may be seen is supported at both ends by means of trolley hangers. The double blade assures excellent contact and large carrying capacity and the double support affords rigidity.

Trade Catalogs

Automatic Pumping — Bulletin 400a of Barrett, Haentjens & Co., Hazelton, Pa., describes the latest developments in automatic pumping. It contains 21 pages.

Gears — Helical gears are described in a leaflet issued by the De Laval Steam Turbine Co., Trenton, N. J.

Motors—Bulletin GEA-435, issued by the General Electric Co., covers multi-speed induction motors for elevator service. Several other bulletins have also been issued by the company. No. GEA-372 covers explosion chambers for high-voltage oil circuit breakers; GEA-399 covers a.c. switchboards with oil circuit breakers for small generating stations and substations; GEA-319, outdoor station equipment—namely, separable post type insulators for use on switching equipments for 88,000 to 220,000 volts.

Coupling—Bulletin 108 of the Poole Engineering & Machine Co., Baltimore, Md., describes the Poole all-metal flexible coupling.

Motor Control — The story of the progress made in development of motor-control apparatus is told in the latest Cutler-Hammer publication, "Industry's Electrical Progress." A copy will be sent free upon request made to the Cutler-Hammer Manufacturing Co., Milwaukee, Wis.

Sand Pumps — Bulletin 266 of the Byron Jackson Pump Manufacturing Co., of Berkeley, Calif., describes rubber-lined sand or sluice pumps. The pump is of the centrifugal type with wearing parts covered with soft rubber which is vulcanized upon a layer of hard rubber molded to the metal surfaces. The bulletin contains prices and performance curves as well as dimensions.

The Market Report

Non-Ferrous Metals Continue Active

Copper Established at 14.25c. Delivered—Lead Prices Firm and Steady, With Slight Sag in Zinc—Tin Quiet

New York, July 21, 1926—The activity in non-ferrous metals, which, with respect to copper particularly, received considerable impetus last week, has continued during the week ended today. Copper was again the leader, and apparently the 14.25c. level for Eastern delivery has been fairly well established. Lead buying continues unabated, with the price, if anything, firmer than a week ago. Zinc showed a tendency to sag, but traders and speculative buyers have entered the market. Prices for tin and antimony both have improved.

Daily Prices of Metals

July	Copper N. Y. net refinery*	Tin		Lead		Zinc
	Electrolytic	99 Per Cent	Straits	N. Y.	St. L.	St. L.
15	13.95	61.125	63.125	8 50	8 35@8.50	7.50@7.60
16	14.00	61.125	63.25	8 50	8 35@8.50	7.45@7.50
17	14.00	61.125	63.25	8 50	8.35@8.525	7.475
19	14.00	61.50	63.625	8.50	8.35@8.50	7 425@7.50
20	14.00	62.00	63.625	8.50	8.35@8.50	7.45@7.50
21	14.00	61.875	63.375	8.50	8.35@8.45	7 45@7.50
Av.	13.992	61.458	63.375	8.500	8.423	7.485

The prices correspond to the following quotations for copper delivered: July 15th, 14.20c.; July 16th, 17th, 19th, 20th and 21st, 14.25c.

The above quotations are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for deliveries constituting the major markets, reduced to the basis of New York cash, except where St. Louis is the normal basing point, or as otherwise noted. All prices are in cents per pound. Copper is commonly sold "delivered," which means that the seller pays the freight from the refinery to the buyer's destination.

Quotations for copper are for ordinary forms of wire bars, ingot bars and cakes. For ingots an extra of 0.05c. per lb. is charged and there are other extras for other shapes. Cathodes are sold at a discount of 0.125c. per lb.

Quotations for zinc are for ordinary Prime Western brands. Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

London

July	Copper			Tin		Lead		Zinc	
	Standard		Electrolytic						
	Spot	3M		Spot	3M	Spot	3M	Spot	3M
15	58¼	59⅛	66	280¼	280	31⅞	31¾	34⅛	34⅜
16	58	58⅜	66	280½	280	32	31 13/16	33 15/16	34 3/16
19	57⅞	58⅝	65½	282½	281	32⅛	31⅞	33⅞	34¼
20	57½	58⅜	65½	285	282¾	32 7/16	32 1/16	34	34 7/16
21	57¾	58½	66	285⅛	282½	32¼	31⅞	33 15/16	34 5/16

The above table gives the closing quotations on the London Metal Exchange. All prices in pounds sterling per ton of 2,240 lb.

Silver, Gold, and Sterling Exchange

July	Sterling Exchange "Checks"	Silver		Gold London	July	Sterling Exchange "Checks"	Silver		Gold London
		New York	London				New York	London	
15	4 85¾	65⅛	30	84s 9¾d	19	4 85⅞	64⅝	29¾	84s10½d
16	4 85⅞	64⅞	29 13/16	84s10½d	20	4.86	64¼	29⅝	84s10½d
17	4 85⅞	64⅞	29 13/16	.....	21	4 85⅞	64¼	29 9/16	84s10½d

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London silver quotations are in pence per troy ounce of sterling silver, 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command one-half cent premium.

Brisk Copper Buying

Though the aggregate sales for the week ended today are somewhat under the exceptionally high figure of last week, an excellent business was done each day since last Wednesday, with the exception of Saturday, when both buyers and sellers took a holiday. The range in prices has been wide. Until today large tonnages were traded at 14.175c. in the East, whereas at the same time other sellers were getting 14.20c. and 14.25c., in the East, and 14.375c. in the Middle West. One or two large buyers have placed large orders for October delivery at 14¼c., while the lower figures quoted were principally for August and August-September positions. The quotations in the accompanying table are weighted averages of all the business done. Figures just released by the American Bureau of Metal Statistics show a decrease of 263 tons in the average daily rate of world copper production for June.

Lead Active at Unchanged Levels

Though London prices advanced daily during the last week until today, no further increase has been made by the leading seller in the New York market. In fact, all sellers seem well content with lead at present prices and are not disposed to make further advances without full justification; they do not wish to see a reaction.

The American Smelting & Refining Co. continues its contract price at 8.50c., New York, and this price has also been obtained by other sellers. A few cars have been sold at premiums of about 10 points, but reputable consumers seem to have no great difficulty in getting the metal for July or August shipment at 8¼c. The demand seems to have been greater in the Middle West than in the East. There, the leading producer has maintained his price for July and August lead at 8.35c. all week, but has only limited amounts to sell, so that a good business has been done by others at from 8.40 to 8.50c. Some of these sellers have released lead a little more freely, especially on last Thursday. Today lead was offered at 8.45c., St. Louis, and it is doubtful if more than this could have been obtained for any appreciable quantity.

The lead market may be characterized as firm and active, with some producers practically sold out of early positions, but with others holding sufficient stocks so that consumers need feel no alarm about supplies. Whether or not a further advance in prices will be made depends largely on the action of the London market in the next few days.

Tin Shows Little Change

Tin prices have continued about the same as they were a week ago, with near-by Straits commanding slightly

above 63c., and discounts of ⅛ to ¼c. being made for forward positions. Demand has been spotty, not a great deal of interest being shown.

Zinc Slightly Easier

Traders have been active in the zinc market; then, too, the demand on the part of consumers, especially brass makers, has been up to the average. In spite of the apparently bullish statistics recently issued, the market eased slightly on Monday, but the tone was better yesterday and today. High-grade delivered in New York is quoted at 9c. per pound.

Francs Under 2c.; Lire Weak

French political conditions continued in a bad way, and with no stable financial policy yet adopted, the franc dropped below 2c. Lire have also been weak, with foreign exchange dealers pessimistic as to the future of that currency also. Closing cable quotations on Tuesday, July 20, were as follows: francs, 1.96c.; lire, 3.1925c.; and marks, 23.81c. Canadian dollars, ½ per cent premium.

Silver Lower

Weakness on the part of India and China depressed silver during the last week, and the decline carried quotations down to 29 5/16d. in London and 64¼c. in New York, which level has not been reached since April 28th. The market shows somewhat more resistance at the lower prices, and some recovery would not be surprising.

Mexican Dollars (Old Mexican pesos): July 15th, 49⅞c.; 16th and 17th, 49⅝c.; 19th, 49⅜c.; 20th and 21st, 49c.

Other Metals

Quotations cover large wholesale lots unless otherwise specified

Aluminum—99 per cent grade, 27@28c. per lb.; 98@99 per cent, 27c.; 94@99 per cent, 26c. London, 98 per cent, £116@£118 per long ton.

Antimony—Per pound, duty paid, New York: Chinese brands, spot, 14@14½c. August arrival, 13½@14¼c. Cookson's "C" grade, spot, 18c. Market firmer with buying by consumers and dealers.

Bismuth—Per pound, New York, in ton lots, $2.70@$2.75. London, 10s.

Cadmium—Per pound, New York, 60c. London, 1s. 10½d. for American metal; 1s. 9d. for Australian metal.

Iridium—Per ounce, $125@$135 for 98@99 per cent. Nominal. London, £63@£65 in iridio-platinum.

Nickel—Per pound, ingot, 35c.; shot, 36c.; electrolytic, 39c. (99.75 per cent grade). London, £170@£175 per long ton according to quantity.

Osmium—Per ounce, $65@$75; London, £17@£20.

Palladium—Per ounce, $70@$72. Pure metal as a constituent of crude platinum, $60@$65 per oz. London, £12@£15, nominal.

Platinum — Refined, per ounce, officially quoted, $115. Sales also at $112@$113. Pure metal as a constituent of crude platinum, $109. Market has stiffened in the last few weeks; better buying.

London, £23½ per ounce for refined, and £20½@£21 for crude. Demand limited.

Quicksilver—Per 75-lb. flask, $90.50@$91.50. Market is firm for futures; weaker for spot. San Francisco wires $90; steady. London £15.

Ruthenium—Per ounce, $60@$70, nominal; London, £12@£15.

The prices of **Cobalt, Germanium Oxide, Lithium, Magnesium, Molybdenum, Monel Metal, Radium, Rhodium, Selenium, Tantalum, Tellurium, Thallium, Tungsten,** and **Zirconium** are unchanged from the issue of July 3.

Metallic Ores

Tungsten Ore—Per unit of WO_3, N.Y.: Wolframite, $10.50@$10.60; Western scheelite, $10.75. Market continues exceedingly dull.

Vanadium Ore—Containing 4 to 8 per cent V_2O_5, 30@35c. per pound of V_2O_5 f.o.b. Montrose, Colo.

Foreign concentrate (lead vanadate) 12 to 18 per cent V_2O_5, 60@65c. per pound V_2O_5, duty paid, seaboard.

Chrome Ore, Iron Ore, Manganese Ore, Molybdenum, Tantalum, and **Uranium** are unchanged from quotations in the July 3 issue.

Lead Ore Higher; Zinc Blende Unchanged

Joplin, Mo., July 17, 1926

Zinc Blende	Ton
High	$53.80
Premium blende, basis 60 per cent zinc	$51.00@52.00
Prime Western, basis 60 per cent zinc	50.00
Fines and slimes, 60 per cent zinc	49.00@45.00
Average settling price, all zinc	47.85
Galena	
High	$106.20
Basis 80 per cent lead	105.00
Average settling price, all zinc	47.85

Shipments for the week: Blende, 16,087; lead, 2,815 tons. Value all ores the week, $1,056,730.

With a production of 13,000 tons and sale of 8,500 tons of blende, there remains in the bins 25,000 tons of zinc concentrate, about three-fifths of which is sold, lowering the unsold stock to approximately 10,000 tons. The holders of this tonnage expect to realize a further advance in price before disposing of it. General resumption of mining has occurred, and the output will probably return to around 15,000 to 16,000 tons during the remainder of this month.

Platteville, Wis., July 17, 1926.

Zinc Blende	Per Ton
Blende, basis 60 per cent zinc	$52.75
Lead Ore	
Lead, basis 80 per cent lead	$100.00

Shipments for the week: Blende, 1,066 tons; lead, none. Shipments for the year: Blende, 28,939; lead, 752 tons. Shipments for the week to separating plants, 2,361 tons blende.

Non-Metallic Minerals

Amblygonite, Asbestos, Barytes, Bauxite, Borax, Celestite, Chalk, China Clay, Diatomite, Emery, Feldspar, Fluorspar, Fuller's Earth, Garnet, Gilsonite, Graphite, Greensand, Gypsum, Ilmenite, Iron Oxide, Lepidolite, Limestone, Magnesite, Mica, Monazite, Ocher, Phosphate, Potash, Pumice, Pyrites, Quartz Rock Crystal, Rutile, Silica, Spodumene, Sulphur, Talc, Tripoli, and **Zircon** are unchanged from prices in the July 3 issue.

Mineral Products

Arsenious Oxide (White arsenic)—3½c. per lb. Occasional carlots sold. London, £14 per long ton.

Copper Sulphate, Sodium Nitrate, Sodium Sulphate (Salt Cake), and **Zinc Oxide** are unchanged from prices in the July 3 issue.

Ferro-Alloys

Ferromanganese — Domestic, 78@82 per cent, $88@$90 per gross ton, furnace; prompt and future.

Ferrosilicon — Per gross ton, f.o.b. works: 50 per cent, $85 delivered in carload lots; 75 per cent, $145; 14-16 per cent, $45.

Ferrotungsten—Per pound contained W. f.o.b. works according to grade, $0.95@$1.

Ferrocerium, Ferrochrome, Ferrophosphorus, Ferrotitanium, Ferrouranium, Ferrovanadium, and **Spiegeleisen** are unchanged from prices in the July 3 issue.

Metal Products

Rolled Copper—Per pound, sheets, 22½c.; wire, base price, 16c.

Lead Sheets—Rolled, 12½c.; clipped, 12½c.

Nickel Silver—29½c. per lb. for 18 per cent nickel Grade A sheets.

Yellow (Muntz) Metal — Dimension sheets, 20½c. per lb.; rods, 17½c. per lb.

Zinc Sheets—Per pound, f.o.b. works, 11¾c.

Refractories

Chrome Brick, Firebrick, Magnesite Brick, Silica Brick, and **Zirkite** are unchanged from prices in the July 3 issue.

Steel Prices Steady and Firm—Pig Iron Dull—Coke Lower

Pittsburgh, July 20, 1926

Steel bookings in general are likely to run somewhat lighter this month than last, but a few trends in the opposite direction have been reported. As July is ordinarily a dull month, and there was some forward buying in bars, shapes, and plates prior to July 1, the general showing is very favorable, particularly if allowance be made for seasonal variation.

Steel prices are holding very well all along the line. Bars, shapes, and plates are at least firmer than two months ago, though by no means has the recently attempted $2 a ton advance in these products been a complete success. Sheet prices have lost no ground in the last thirty days, and predictions are growing common that they will soon work their way upward.

Pig Iron—The Valley market remains dull. Bessemer, $19; basic, $17.50; foundry, $17.75, f.o.b. Valley furnaces.

Connellsville Coke — Spot furnace coke has eased off since the holiday advance, being now $2.75@$2.85. Standard grade foundry coke remains at $4@$4.50.

Company Reports

Union Miniere Income for 1925 Totaled 274,000,000 Francs

The report of Union Minière du Haut-Katanga, the big African copper enterprise, for 1925 will show income of 274,000,000 francs, comparing with 111,715,401 francs in 1924 and 78,872,755 francs in 1923, according to the *Boston News Bureau*. This includes the premium paid on capital stock issued during the year. Net profits available for surplus amounted to nearly 120,000,000 francs.

Ore reserves at the end of the year amounted to nearly 77,000,000 tons averaging 6.87 per cent copper.

Ore deposits, plants, equipments, and other property are carried in the balance sheet at 280,000,000 francs, less amortization reserves of 139,000,000 francs.

During the year the pilot flotation plant worked satisfactorily, and it will be enlarged.

Reduction in the output the first six months of this year compared with the same period last year was due to lack of native labor.

Copper production in 1925 amounted to 90,104 long tons, or 201,832,960 lb., comparing with 188,647,622 lb. in 1924.

The company will increase the capacity of its reverberatory furnaces to produce from 30,000 to 40,000 tons of copper, or 67,000,000 to 90,000,000 lb. annually during 1926.

Mining Corporation and Lorrain Trout Lake Issue Quarterly Reports

The quarterly report of the Mining Corporation of Canada, Ltd., for the period ended June 30, 1926, shows that development work at the Cobalt Lake property was satisfactory, drifting having put in sight additional new ore at least equal to that extracted. Development of the oreshoot at the Townsite-City property was extended and the mill of the Cobalt Reduction Co. was operated at capacity on Cobalt and South Lorrain ore. No outstanding ore developments were made at the South Lorrain properties. The average grade of ore from Cobalt and South Lorrain was 27.66 oz. of silver per ton, and the total silver production for the period was 563,780 oz. Development continues at the Cryderman property, in Manitoba.

Production was somewhat curtailed by the Lorrain Trout Lake Mines, Ltd., of which the Mining Corporation owns one-third (500,000 shares) of the capital stock, owing to preparations for development at depth. The assay of mill ore for the quarter was 23.65 oz. of silver, and the total production, 27,154 oz.

Sharpe More Optimistic on World Zinc Industry

A. J. M. SHARPE, of International Metal Service, London, and honorary foreign correspondent of the American Zinc Institute, has the following to say in his monthly letter dated July 1:

"It is a pleasure to be able to write more hopefully on the zinc situation; I am convinced that before long my predictions of better times for the world zinc industry will be fulfilled.

"The improvement which is being gradually wrought in the position is the more gratifying when it is remembered that British consumption has suffered a reduction of around 50 per cent since the coal miners ceased work on the first of last May.

"Having regard to the fact that Europe was producing more than enough slab zinc for its own purposes during the first four months of the year, those not immediately on the scene are finding it difficult to appreciate the fundamental reasons for the improving tendency. Primarily, this may be ascribed to the boom in sheet zinc. All the German output is being rolled, as is also a preponderance of the Belgian and Silesian production; while the French output is principally divided by the manufacturers of sheets and oxides. The zinc rollers, like other sections of the metal trades in Europe, enjoy their eras of prosperity and suffer periods of depression; at present they are so fully booked with business as to make it wellnigh impossible to accept fresh orders for delivery earlier than two months. These fabricating trades are also benefiting from the fresh plans of the German Government to speed up building construction to overcome the housing shortage.

"In view of the substantial improvement in Continental consumption, it does not need much imagination to envisage the increased activity which must take place when the British coal crisis is ended and British consumption expands to its normal level of 14,000 tons to 15,000 tons monthly. *I make bold to say that there is a distinct possibility of the necessity arising for American slab zinc to be imported into England again before the end of the year.*

"British production of zinc has wholly stopped, the smelters finding it impossible to dispose of their acid in present circumstances, and this condition must apply until the coke ovens are again operating.

"The Belgian output has reached its pre-war scale.

"The only comment I feel constrained to proffer on the American situation is that the recent curtailment in zinc-ore and metal production is good policy and that it will be disappointing if producers yield to the temptation of higher market prices and raise the output. In the interest of the United States industry, it would be prudent to keep the production of slab zinc to the level of domestic consumption. World stocks July 1:

	Metric Tons
United States	23,400
Canada	2,100
Australia (including unsold shipments afloat)	2,200
Germany and Poland	6,500
Belgium	1,800
France	1,200
Great Britain	1,200
Scandinavia	200
Far East	500
Elsewhere	1,500
Total	40,600"

New Corporation Formed to Exploit Chromium Plating

Evidence of the growing importance of chromium as a commercial metal apart from its use as an alloy is afforded by the organization of the Chromium Corporation of America, announced this week. The company will take over the chromium plating patents of the Chemical Treatment Co. and the Chromium Products Corporation, the last named being one of the subsidiaries of the Metal & Thermit Corporation. Chromium, by virtue of its great hardness and noncorrosive qualities, together with its bright silvery appearance, is likely to prove a metal of much wider use now that commercial plating methods have been developed.

John T. Pratt will be chairman of the board of the new corporation, and has released the following information:

"The two companies whose chromium plating interests are now being taken over by the new Chromium Corporation of America have been the pioneers in the commercial development of this new art. In taking over the Fink and Grube patents, as well as others controlled by one or the other of the companies mentioned, the Chromium Corporation of America will own or control strong basic patents covering chromium plating under all conditions which are commercially feasible. It will also be allied with the rapidly developing German interests.

"Operating under the basic Grube process patent the Metal & Thermit Corporation, and later its subsidiary, the Chromium Products Corporation, has maintained and operated an extensive and well-equipped chromium-plating plant in Jersey City in which it has been producing chromium-plate in considerable volume for manufacturers of such products as plumbing fixtures, hardware, brake drums, reflectors, steel tubing, bearings of various types, electrical contact points, heat-control devices, radiator shells, and various automobile accessories. In addition it has concluded certain license agreements.

"Working along similar if not exactly parallel lines, the Chemical Treatment Co., operating under the process patents of Dr. Colin G. Fink, the eminent electro-chemist of Columbia University, who is internationally famed for his basic discoveries in chemical metallurgy, has built up a large business and wide acceptance for a special type of chromium plating under its trade name 'Crodon.' The Chemical Treatment Co. has been producing Crodon in its plants in New York City and Waterbury, Conn.

"The new corporation will take over and operate the Chromium Products plant in Jersey City and the Chemical Treatment plants in New York and Waterbury. Plans are

also being formulated for the opening of new plants at Carteret, N. J.; East Chicago, Ind.; and South San Francisco, in each of which the Metal & Thermit Corporation now has plants; as well as in Chicago, Detroit, Cincinnati, Akron, Philadelphia, Pittsburgh, and Cleveland. The company's expansion program contemplates a national service.

"Having taken over the Chemical Treatment Co., and its trade name Crodon which will hereafter stand for chrome plate as applied by the Chromium Corporation of America or its licensees, the new company will initiate immediately an intensified selling, merchandising, and engineering campaign which will cover manufacturers of certain types of metal products throughout the country. The Chemical Treatment Co. policy of limiting the use of Crodon to manufacturers of quality products will be rigidly adhered to. At the same time, the educational advertising will be intensified."

Distribution of Mining Shares

The following shows the number of shareholders on the record of various mining companies at recent dates, compiled by William Jones, auditors, of New York City.

590 Adargas Mining Co.
16,640 American Smelting & Refining Co.
700 Amparo Mining Co.
16,800 Anaconda Copper Mining Co.
510 Apex Porcupine Mines, Ltd.
1,800 Argonaut Gold, Ltd.
563 Arizona Silver Mines Co.
500 Atlas Gold Mines, Ltd.
1,350 Bailey Silver Mines, Ltd.
1,080 Baldwin Gold Mining Co., Ltd.
250 The Banner Mines, Inc.
230 Barry - Hollinger Mines, Ltd.
1,750 Beaver Consolidated Mines, Ltd.
300 Blue Monster Copper Co.
400 Blue Quartz Gold Mines, Ltd.
6,800 Boston Montana Corporation
1,000 Boston Creek Mining Co.
550 British Matachewan Gold Mines, Ltd.
250 Buckingham Mines, Ltd.
275 Bully Boy Mines Corporation
3,550 Callahan Zinc & Lead Co.
5,500 Calumet & Hecla Mining Co.
3,350 Canadian Associated Goldfields, Ltd.
1,400 Candelaria Mines Co.
400 Castle Trethewey Mines, Ltd.
6,200 Cerro de Pasco Copper Corporation
750 Chambers-Ferland Mining Co., Ltd.
900 Cobalt Frontenac Mining Co., Ltd.
3,800 Cobalt Silver Queen, Ltd.
275 Columbus Mining Co. of Coeur d'Alene
722 Coniagas Mines Co.
2,175 Consolidated West Dome Mines, Ltd.
350 Cortez Silver Mines Co.
3,500 Crown Reserve Mining Co., Ltd.
1,000 Davidson Mines Co., Ltd. (The)
1,165 Dome Extension Mines, Ltd.
622 Dome Lake Mining & Milling Co.
3,200 Dome Mines Co. (The)
1,600 Eureka Croesus Mining Co.
2,329 Federal Mining & Smelting Co.
2,800 Fortuna Consolidated Mining Co.
1,400 Franklin Mining Co.
525 Genesee Mining Co.
225 Goldale Mines, Ltd.
600 Gold Centre Mines, Ltd.
469 Golden Summit Mining Co., Ltd.
225 Goodfish Gold Mines, Ltd.
2,300 Granby Consolidated Mining, Smelting & Power Co.
1,720 Hargrave Silver Mines, Ltd.
400 Hattie Gold Mines, Ltd.
1,800 Hecla Mining Co.
221 Herrick Gold Mines, Ltd.
5,100 Hollinger Consolidated Gold Mines, Ltd.
6,150 Huron Copper Mining Co.
2,700 Keeley Silver Mines, Ltd. (The)
27,500 Kennecott Copper Corporation
2,880 Kerr Lake Mines, Ltd.
1,250 Lake Copper Co.
360 Lake Matachewan Gold Mining Co., Ltd.
1,277 Lake Shore Mines, Ltd.
450 La Mine d'Or Huronia, Ltd.
6,020 La Rose Mines, Ltd.
400 Lightning River Gold Mines, Ltd.
760 Lorrain Consolidated Mines, Ltd.
1,470 Massachusetts Consolidated Mining Co.
2,700 McIntyre Porcupine Mines, Ltd.
4,908 McKinley-Darragh-Savage Mines, Ltd.
247 Michigan Smelting & Refining Co.
1,400 Mildred Gold Mining Co.
1,310 Mining Corporation of Canada, Ltd.
2,500 Mohawk Mining Co.
1,400 Newray Mines, Ltd.
1,400 New York-Bingham Mining Co.
285 Night Hawk Peninsular Mines, Ltd.
11,679 Nipissing Mines Co., Ltd.
730 North Lake Mining Co.
2,700 Ore Chimney Mining Co.
2,515 Peterson Lake Silver Cobalt Mining Co., Ltd.
2,125 Porcupine Crown Mines, Ltd.
400 Porcupine Gold Reef Mining Co., Ltd.
700 Porcupine Keora Mining Co., Ltd.
900 Porcupine V. N. T. Gold Mines, Ltd.
1,464 Preston East Dome Mines, Ltd.
850 Rand Mines, Ltd.
5,100 Ray Hercules Copper Co.
600 Right of Way Mines Co.
382 Rochester Mines, Ltd.
872 Rose Gold & Silver Mining Co., Ltd.
1,850 Seneca Copper Corp.
4,800 Silver Leaf Mining Co., Ltd.
950 Sinaloa Exploration & Development Co.
2,754 Teck-Hughes Gold Mines, Ltd.
2,322 Temiskaming Mining Co., Ltd.
2,000 Tennessee Copper & Chemical Co.
525 Thompson Krist Mining Co.
2,520 Tonopah Extension Mining Co.
800 Tough Oakes Burnside Gold Mines, Ltd.
1,944 Trethewey Silver Cobalt Mines, Ltd.
14,755 United States Smelting, Refining & Mining Co.
726 United Zinc Smelting Corp.
1,364 Vipond Consolidated Mines, Ltd.
541 Wasapika Consolidated Mines, Ltd.
1,523 Wettlaufer-Lorraine Silver Mining Co., Ltd.
1,800 Winona Copper Co.
450 Wright-Hargreaves Mines, Ltd.
400 Wyandot Copper Co.

German Metal Markets Continue Quiet—Imports Higher

By Dr. James Rubenfeld
Special Correspondent, Berlin

DESPITE the steadily though slowly progressing stabilization of the whole economic system of this country, the metal markets here are still somewhat subdued. The main reasons are no longer money difficulties, for there is plenty of loan money at reasonable rates; but the reorganization of the producing and consuming units, readjustment in working methods on the much-favored American system. Unemployment and reduction of consuming power of the population are factors. Manufacturers have assumed an attitude of caution when ordering metals abroad. From this policy they would not depart even when the formation of the Copper Export Trading Co. appeared likely to drive prices of the metal to higher levels.

Imports of metallic rawstuffs during the first five months of the current year in round figures are as shown in the following table:

German Metal Imports January-May
In Metric Tons

	1926	1925		1926	1925
Copper	48,150	104,562	Aluminum	1,450	5,341
Lead	29,330	70,762	Nickel	620	1,463
Zinc	29,353	47,184	Antimony	807	1,193
Tin	2,006	6,474			

In discussing the Copper Export Trading Co., traders are inclined to argue that producers will never be able to adapt themselves to credit needs and habits of Europe, since Americans are wont to contract cash against documents. Further, it is pointed out that when industrial activity once again has set in, there will be much old metal and residues with which consumers and jobbers alike will trade against electrolytic copper.

On the other hand, the tin refinery of Wilhelmsburg, near Hamburg, that last September was taken over by the Williams Harvey Co. (subsidiary of the National Lead Co.), is to begin smelting operations within a few months, as the rumor goes. Because of low returning charges in northern Germany and of the acquisition of cheap Bolivian tin ores, the promoters of the scheme, the Williams Harvey Co. and Brandeis, Goldschmidt & Co., believe that the time is ripe for resuming work, which has been suspended for a long time. The resumption of smelting operations in the Wilhelmsburg refinery will mean something for Germany, where tin ore smelting had fallen away to almost nothing. Imports of tin ore during the months January-May, 1926, have been about 260 tons, as compared with some 18,000 tons for the year 1913.

Outlook Is Encouraging

The trend to the resumption of a self-supporting basis is unabated here; the outstanding example is the raw aluminum industry, which is able to oust even the relatively cheap American-owned aluminum of Norwegian origin which in the years just past could well rival that of the Vereinigte Aluminiumwerke Aktiengesellschaft of Lauta. Now, however, the hydro-electric works of the Innwerk (Bavaria) permit cheap manufacturing costs and low overhead charges. For a paid-up capital of 24,000,000 marks the Lautawerke has made a net profit in the last year of 4,000,000 and paid a dividend of 7½ per cent. At present the market for aluminum remains quiet, but a revival of demand is looked for, as there are already many excellent "German" aluminum alloys which are becoming more and more favored. Surely it may be said that, as far as Germany is concerned, aluminum is to hold its own beside copper. Because Italy will increase the already too heavy exports of bauxite which she reserves for the Montecatini company, of Milan, and for enlarging her aluminum industry, the Lautawerke has acquired bauxite mines in Hungary and elsewhere.

It may be mentioned that the concession on the Arghana copper mine, which had been granted by the Turkish Government to the Deutsche Bank, Beer, Sondheimer & Co., Metallgesellschaft, and Otto Wolff, has been abandoned voluntarily by this consortium, for the Turks had insisted on a very expensive railway line which would serve military purposes, too.

Mining Stocks—Week Ended July 17, 1926

Stock	Exch.	High	Low	Last		Last Div.
COPPER						
Anaconda	New York	50	47¼	50	Jy.17, Au.23 Q	0.75
Arcadian Consol.	Boston	1⅛	*60	1⅛		
Ariz. Com'l	Boston	12½	11⅛	12⅛	Jy. 16, Jy. 30	0.50
Calaveras	N. Y. Curb	1⅛		1⅛		
Calumet & Arizona	New York	70	67½	69½	Jn. 4, Jn. 21 Q	1.50
Calumet & Hecla	Boston	15⅛	14	15⅛	Jn. 1, Jn. 15 Q	0.50
Cerro de Pasco	New York	68⅛	65⅛	68	Jy. 15, Au. 2, Q	1.00
Chile Copper	New York	34⅜	33⅛	33⅜	Jn. 2, Jn. 28, Q	0.62½
Chino	New York	23¼	23⅛	23⅛	Sept., 1920	0.37½
Con. Coppermines	N. Y. Curb	3⅛	3⅛	3⅛		
Copper Range	Boston	18	14⅛	17⅛	May, 1925	1.00
Crystal Copper	Boston Curb	*39	*33	*34		
East Butte	Boston	3⅛	3	3⅛	Dec., 1919	0.50
First National	Boston Curb	*20	*16	*20	Feb., 1919	0.15
Franklin	Boston	*60	*60	*60		
Granby Consol.	New York	24⅛	21⅛	23⅛	May, 1919	1.25
Greene-Cananea	New York	17⅛	16⅛	17⅛	Nov., 1920	0.50
Hancock	Boston	1⅛	1	1⅛		
Howe Sound	New York	39	37⅛	38⅛	Ap.1, Ap.15	0.75
Inspiration Consl.	New York	25⅞	23⅛	25⅛	Jn.7, Jy.6, Q	0.50
Iron Cap	Boston Curb	3⅛	3⅛	3⅛	Jn. 1, Jn. 15	0.50
Isle Royale	Boston	13⅛	10	13⅛	Jn. 1, Jn. 15	0.50
Jerome Verde Dev	N. Y. Curb	*66	*60	*66		
Kennecott	New York	47	54⅛	56⅛	Jn. 4, July 1 Q	1.00
Lake Copper	Boston	1⅛	*95	1½	June, 1925	0.50
Magma Copper	New York	42⅛	38⅛	42⅛	Jn.30, July.15, Q	0.75
Mason Valley	N. Y. Curb	2	1⅛	1⅛		
Mass Consolidated	Boston	*50	*30	*45	Nov., 1917	1.00
Miami Copper	New York	15⅜	14⅛	15⅛	Aug.2, Aug.16 Q	0.25
Mohawk	Boston	39¼	34	38⅛	My.1, Je.1 Q	1.00
Mother Lode Coa	New York	6	5⅛	6	Jn. 15, Jn. 30	0.37½
Nevada Consol.	New York	14⅛	13⅛	14⅛	Jn. 15, Jn. 30 Q	0.25
New Cornelia	Boston	23⅛	21⅛	23⅛	My.7, M.24 Q	0.40
North Butte	Boston	2⅛	2⅛	2⅛	Oct., 1918	0.25
Ohio Copper	N. Y. Curb	*62	*60	*62	No. 14, De. 2	0.05
Old Dominion	Boston	20	16	19⅜	Dec., 1918	1.00
Phelps Dodge	Open Mar.	†125	†122		Jun.22, July2 Q	1.50
Quincy	Boston	25	18	24⅛	Mar., 1920	1.00
Ray Consolidated	New York	14⅛	14	14⅛	Ap.20, Ap.30	0.25
Ray Hercules	N. Y. Curb			11⅛		
St. Mary's Min. Ld.	Boston	33	28	32⅛	Ap.17, My.18	2.00
Seneca Copper	New York	7⅛	5⅛	6⅛		
Shannon	Boston	*65	*36	*65	Nov., 1917	0.25
Superior & Boston	Boston	*90	*75	*90		
Tenn. C. & C.	New York	12⅛	11⅛	12⅛	My. 29 Ju. 15, Q	0.25
United Verde Ex	N. Y. Curb	28⅛	27⅛	28⅛	Jy.17, Aug. 2,	0.75
Utah Copper	New York			100	Jn.15, Jn.31, Q	1.25
Utah Metal & T	Boston	1⅛	1 1/16	1 1/16	Dec., 1917	0.30
Victoria	Boston	*50	*50	*50		
Walker Mining	Salt Lake	*75	*53	*55		
NICKEL-COPPER						
Internat. Nickel	New York	40⅛	36⅛	40	Jn.30, Ju.15, Q	0.62½
Internat. Nickel, pfd.	New York			104	Ap.15, My.1, Q	1.50
LEAD						
Gladstone M. M. Co.	Spokane	*29½	*28	*28½	Jn. 10, July 10	0.1½
National Lead	New York	163⅛	156	162⅛	Jn. 11, Jn. 30 Q	2.00
National Lead pfd	New York	116⅛	116⅛	116⅛	My.21, Je.15 Q	1.75
St. Joseph Lead	New York	42⅛	41	42⅜	Jn.10, Jn.21 QX	0.75
ZINC						
Am. Z. L. & S.	New York	8⅛	7⅛	8⅛	May., 1920	1.00
Am. Z. L. & S, pfd.	New York	39⅛	33	38⅛	Nov., 1920	1.50
Butte C. & Z.	New York	5⅛	5	5⅛	De.10, De.24	0.50
Butte & Superior	New York	11⅛	10⅛	11⅛	Jn.15, Jn.30 Q	0.50
Callahan Zn-Ld	New York	1⅛	1⅛	1⅛	Dec., 1920	0.50
Eagle Picher	Cincinnati	33⅛	30	30⅛	My. 15, Jn.1	0.40
Eagle Picher, pfd	Cincinnati			110	Jn.30, Jy.15 Q	1.50
New Jersey Zn	N. Y. Curb			208	Jn.9, Jy.10 Q	2.00
United Zinc	N. Y. Curb			*70		
Yellow Pine	Los Angeles	*25	*25	*25	De.8, De.18 Q	0.04
GOLD						
Alaska Juneau	New York	1⅛	1⅛	1⅛		
Argonaut	Toronto	*20	*18⅛	*18⅛		
Barry-Hollinger	Toronto	*47½	*46⅛	*46⅛		
Carson Hill	Boston	*30	*30	*30		
Consol. W. Dome L.	Toronto	*15⅛	*15	*15⅛		
Cresson Consol. G.	N. Y. Curb	2⅛	2⅛	2 1/16	Mh.31, Ap.10	0.10
Crown Reserve	Toronto	*14	*10⅛	*11	Jan., 1917	0.05
Dome Mines	New York	11⅛	10⅛	11	Jn.30, July 20, Q	0.50
Golden Center	N. Y. Curb	1⅛	1⅛	1⅛		
Golden Cycle	Colo. Springs	1.50	1.50	1.50	No.30, Dec.10 Q	0.03
Hollinger Consol	Toronto	19.65	19.10	19.65	Jn.29, Jy.15 Q	0.10
Homestake Mining	New York	54⅜	54⅛	54⅛	Jy.20, Jy.26 M	0.50
Kirkland Lake	Toronto	1.03	*9 7	*97		
Lake Shore	Toronto	11.55	11.30	11.55	Jn.1, Jn. 15 Q	0.10
McIntyre-Porcupine	New York	25⅛	24⅝	25⅛	Au.7, Se.1	0.25
Newray	Toronto	*32	*32	*32		
Noranda	N. Y. Curb	17⅛	15⅛	17		
Portland	Colo. Springs	*44	*44	*44	July6, July15	0.02
Rand Mines	New York	34⅛	34⅛	34⅛	Fe.16, Fe.26	1.52
Teck-Hughes	Toronto	3.88	3.80	3.81	Jy. 15, Au. 2	0.05
Tom Reed	Los Angeles	*62⅛	*60	*60	Ma.10 Ma.20	0.02
Tough-Oakes	Toronto	*46	*39	*39		
United Eastern	N. Y. Curb			*30	July, 1924	0.05
Vipond Cons.	Toronto	1.78	1.72	1.75		
Wright-Hargreaves	Toronto	8.48	8.40	8.48	Jn.15, Jy.1 Q X	0.07½
Yukon-Alaska Trust	N. Y. Curb			21		
GOLD AND SILVER						
Carnegie Metals	Boston			14½		
Con. Cortez	N. Y. Curb	*5	*5	*5		
Con. Virginia	San Francisco	*6½	*6½	*6½		
Continental Mines	N. Y. Curb			*45		
Dolores Esperanza	N. Y. Curb	*40	*40	*40	July, 1923	0.05
Premier Gold	N. Y. Curb	2⅛	2⅛	2⅛	Jn.18, Jy.3 Q	0.08
Tonopah Belmont	N. Y. Curb	3⅛	3	3	Se.15, Oc.1	0.05
Tonopah Extension	N. Y. Curb	*45	*37	*45	Apr. 1925	0.05
Tonopah Mining	N. Y. Curb	6⅛	6⅛	6⅛	Ap.7, Ap.21 Q	0.07½
Unity Gold	N. Y. Curb			*20		
West End Consol.	N. Y. Curb	*15	*15	*15	Mar., 1923	0.05
Yukon Gold	N. Y. Curb	*30	*30	*30	June, 1918	0.02

Stock	Exch.	High	Low	Last		Last Div.
SILVER						
Alvarado	N. Y. Curb			1	Oct., 1920	0.50
Beaver Consol	Toronto	*82⅛	*80	*80	May. 1920	0.03
Castle-Trethewey	Toronto	1.61	1.49	1.50		
Coniagas	Toronto	3.90	3.60	3.80	May, 1924	0.12½
Keeley	Toronto	1.65	1.56	1.65	Ma.1, Ma.15 X	0.12
Kerr Lake	N. Y. Curb	1	1	1	Ap.1, Ap.15	0.12½
La Rose	Toronto	*11	*10	*11	Apr., 1922	0.10½
Lorrain Trout Lake	Toronto			*85	Jy. 2, Jy. 15	0.05
McKinley-Dar.-Sav	Toronto	*14⅛	*12⅛	*12⅛	Oct., 1920	0.03
Mining Corp. Can	Toronto	3.67	3.40	3.65	Jy.1, Jy.15	0.12½
Nipissing	N. Y. Curb	5⅛	5⅛	5⅛	Jn.30, Jy.20	0.15
Temiskaming	Toronto			*11	Jan., 1920	0.40
SILVER-LEAD						
Ahumada	New York	8⅛	7⅛	8	Jn.18, Jy.5, Q X	0.25
Alta Merger	Salt Lake	†*5⅛	†*2⅛			
Bingham Mines	Boston	34⅛	33⅛	33⅛	Jn.19, Jn.30 Q	1.00
Cardiff M. & M.	Salt Lake	*53	*53	*53	De.16, No.18	0.10
Chief Consol.	Salt Lake	3.10	3.10	3.10	Jy.10, Au.10 Q	0.10
Emma Silver	Salt Lake	†1	†*50			
Erupcion	Boston Curb	1⅛	1 1/16	1 1/16	Jn.18, Jy.5, QX	0.10
Federal M. & S.	New York	74	72	74		
Federal M. & S., pfd.	New York	73⅜	72⅛	72⅛	My.25, Ju.15 Q	1.75
Hawthorne Mines	N. Y. Curb	*18	*15	*17		
Hecla Mining	N. Y. Curb	17⅛	17⅛	17⅛	My.15, Je.15 Q	0.50
Iron King Mining	Salt Lake	*26	*25	*25		
Keystone Mining	Salt Lake	*27	*25	*27	Au.12, Au.26	0.07½
Lucky Jim	Spokane	*18	*17	*17⅛		
Mammoth Mining	Salt Lake	†2.80	†2.75		Mar.24, Apr. 1	0.10
Marsh Mines	Spokane	2⅛	2	2⅛	Se.15, Oc.1	0.15
Park Utah	New York	6⅛	6⅛	6⅛	Jn.15, Jy.1 Q	0.15
Prince Cons	Salt Lake	1⅛	1⅛	1⅛		
Silver King Coal	Salt Lake	9.15	8.95	9.05	Jn. 21, July 1, Q	0.25
Silversmith	Spokane	*46	*45	*46	Jn.30, Jy.10 Q	0.02
Tamarack-Custer	Spokane	*32	*29	*31⅛	Sept., 1924	0.25
Tintic Standard	Salt Lake	12.50	12.50	12.50	Jn.16, Jn.26,	0.40
Utah-Apex	Boston	8	7⅛	8	Jy. 3, Jy.15 Q	0.25
Western Utah Copper	N. Y. Curb			*8		
IRON						
Bethlehem Steel	New York	46⅛	44⅛	44⅞	July, 1924	1.25
Colorado Fuel & Iron	New York	47⅛	43⅛	46⅛	May, 1921	0.75
Gt. North'n Iron Ore	New York	21⅛	21	21	De. 4, De. 28,	0.75
Inland Steel	New York	42⅛	40⅛	40⅛	My.10, Je.1 Q	0.75
Mesabi Iron	N. Y. Curb	1⅛	1⅛	1⅛		
Replogle Steel	New York	10⅛	9⅛	10		
Republic I. & S.	New York	56⅛	55	56	May, 1921	1.50
Republic I. & S. pfd.	New York	96	95⅛	96	Jn.15, July1, Q	1.75
Sloss-Sheffield S. & I.	New York	134	128	131	Jn.10, Jn.21 Q	1.50
Sloss-Shef. S.&I. pfd.	New York			110	Jn.21, July.1, Q	1.75
U. S. Steel	New York	145	139⅛	143⅜	Jn.2, Jn.29 Q	1.75
U. S. Steel pfd	New York	129⅜	128⅛	128⅜	My.4, My.29, Q	1.75
Virginia I. C. & C.	New York	45	45	45	Jan., 1924	1.50
Virginia I.C.&C.pfd	New York	71⅛	71⅛	71⅛	Jn.1, July 2,	2.50
ALUMINUM						
Alum.Co. of Amer	N.Y.Curb	Ind. 73⅛	73⅛	73⅛		
Alum. Co. of Amer pf.	N.Y.Curb	Ind.		99⅜	June 15, July 1, Q	0.01½
VANADIUM						
Vanadium Corp.	New York	37	36⅛	36⅛	My.1, My.15, Q	0.75
ASBESTOS						
Asbestos Corp., New	Montreal	19⅜	18	18	De.31, Ja.15 Q	1.50
Asbestos Corp., pfd.	Montreal	75⅛	72	73⅜	Jy.1, Jy.15, Q	1.75
SULPHUR						
Freeport Texas	New York	33⅛	31⅛	32⅛	Nov., 1919	1.00
Texas Gulf	New York	156	151	154⅝	Jn.1, Jn. 15, Q	2.50
DIAMONDS						
De Beers Consol	New York			35⅛	Ju.16, Ju.17	1.70
PLATINUM						
So. Am. Gold & P	N. Y. Curb	5⅛	4⅛	5		
MINING, SMELTING, REFINING AND GENERAL						
Amer. Metal	New York	54⅛	53⅛	54	My.20, Je. 1, Q	1.00
Amer. Metal pfd	New York			117	My.20, Je. 1 Q	1.75
Amer. Sm. & Ref.	New York	136⅛	131⅛	136⅝	Jy.10, Au.2, Q	1.75
Amer. Sm.&Ref.pfd.	New York	118⅛	118	118	Au.7, Se.1, Q	1.75
Consol. M. & S.	N. Y. Curb			208	Jn.30, Jy.5 QX	3.75
Federated Metals	N. Y. Curb	12⅛	12⅛	12⅜		
Newmont Mining	N. Y. Curb	62	60⅛	61⅛	Mar.31, Apr.15,	0.60
Southwest Metals	N. Y. Curb	1	1	1	Jn.30, Jy.15	0.60
U. S. Sm. R. & M.	New York	42⅛	40	41⅛	Jy. 7, Jy. 15, Q	0.87½
U. S. Sm. R.&M.pfd.	New York	50	48⅛	49⅛	Jy. 7, Jy. 15, Q	1.75

* Cents per share. † Bid or asked. Q, Quarterly. SA, Semi-annually. M, Monthly. K, Irregular. I, Initial. X, Includes extra. The first date given is that of the closing of the books; the second that of the payment of the dividend.

Boston quotations courtesy Boston Stock Exchange; Toronto quotations those of the Standard Stock Exchange of Toronto, by courtesy of Arthur E. Moysey & Co.; Spokane, Pohlman Investment Co.; Salt Lake, Stock and Mining Exchange; Henry Sachs, Colorado Springs, Colo.

PRICE WEEK ENDED JULY 6, 1926

Name	High	Low	Last	Last Divd. Date	Amount
Aramayo Mines (25 frs.)	81/3	78/9	78/9	May. 1926	5 p.c.†
British Platinum (£1)	6/—	5/6	6/—	Feb. 1925	2½ p.c.
Burma Corpn. (10 rupees)	15/9	15/3	15/6	Aug. 1926	7 annas*
Bwana M'Kubwa (5s)	8/3	7/6	8/—		
Camp Bird (£1)	4/9	4/7½	4/9		
El Oro (£1)	6/4½	5/10½	6/4½	Nov. 1924	2½ p.c.*
Esperanza (10s)	1/—	—/10½	6/4½		
Frontino & Bolivia (£1)	7/7½	7/6	7/6	July 1926	2½ p.c.
Mexican Corpn. (£1)	16/6	15/6	16/3	Dec. 1925	12½ p.c.*
Mexico Mines of El Oro (£1)	30/—	28/9	30/—	June 1926	7½ p.c.*
Oroville Dredging (£1)	3/10½	3/9	3/9	Dec. 1923	3½ p.c.
Ouro Preto (£1)	2/1½	2/—	2/—	May 1925	2½ p.c.
Rhodesian Congo Border	126/3	120/—	125/—		
St. John del Rey (£1)	9/1½	9/—	9/—	June 1925	6½ p.c.
San Francisco Mines (10s)	28/1½	27/—	28/—	June 1926	15 p.c.
Santa Gertrudis (£1)	20/9	20/—	20/—	July 1926	5 p.c.
Selukwe (2s. 6d.)	12/6	11/4½	12/4½	April 1917	6¾ p.c.
S. Amer. Copper (2s.)	4/6	4/1½	4/3	Nov. 1917	75 p.c.
Tanganyika (£1)	41/3	38/9	39/4½	Sept. 1925	5 p.c.
Tomboy (£1)	3/9	3/6	3/9	Jan. 1926	5 p.c.
Union Miniere du Haut-Katanga (Brussels)	8.000	7.475	8.000	July 1925	150 frs.‡

* Free of British income tax. † Swiss frs. ‡ Belgian frs.